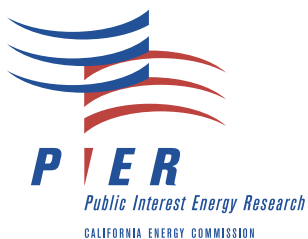


C A L I F O R N I A E N E R G Y C O M M I S S I O N

PUBLIC INTEREST ENERGY RESEARCH

2000 ANNUAL REPORT



GRAY DAVIS, Governor

March 2001
P600-01-007



California Energy
Commission

GRAY DAVIS, Governor

March 31, 2001

Members of the Senate Energy, Utilities and Communications Committee
Members of the Senate Budget and Fiscal Review Committee
Members of the Senate Appropriations Committee
Members of the Assembly Utilities and Commerce Committee
Members of the Assembly Budget Committee
Members of the Assembly Appropriations Committee
California State Capitol Building
Sacramento, California 95814

**Re: The California Energy Commission's 2000 Annual Report Concerning the
Public Interest Energy Research Program**

Dear Members:

In accordance with Public Resources Code Section 25620.8, the California Energy Commission hereby transmits its third Annual Report to the Legislature concerning the Public Interest Energy Research (PIER) Program, for the period January 1 through December 31, 2000. Recent legislation across the nation shows that California's PIER Program is serving as a model for many other states.

This Annual Report provides the following information: (1) a brief background and overview of the program; (2) a current status of the program, including all funding awards made by the Commission as of December 31, 2000; and (3) the Commission's recommended future direction for the PIER Program. The report specifically includes all required information on the "names of award recipients, the amount of awards, the types of projects funded...and recommendations for improvements in the program." However, since some of the projects funded through the PIER Program are multi-year projects and are not yet complete, the required annual "evaluation of the success of [these] funded projects" will be provided in subsequent Semi-annual and Annual Reports on the PIER Program.

Should you have questions or comments concerning this report, please feel free to contact Tim Schmelzer, Energy Commission Director of Governmental Affairs, at 654-4942.

Respectfully submitted,

A handwritten signature in dark ink, reading "Art Rosenfeld".

ARTHUR H. ROSENFELD
Commissioner and Presiding Member
Research, Development and
Demonstration Committee

A handwritten signature in dark ink, reading "Robert A. Laurie".

ROBERT A. LAURIE
Commissioner and Second Member
Research, Development and
Demonstration Committee

cc: California Legislative Analyst Office



P I E R

Public Interest Energy Research

CALIFORNIA ENERGY COMMISSION

Public Interest Energy Research Program

2000 ANNUAL REPORT

March 2001

GRAY DAVIS, Governor

The Resources Agency of California

MARY D. NICHOLS, Secretary

California Energy Commission

WILLIAM J. KEESE, Chairman

MICHAL C. MOORE, Commissioner

ROBERT A. LAURIE, Commissioner

ROBERT PERNELL, Commissioner

ARTHUR H. ROSENFELD, Commissioner

STEVE LARSON, Executive Director





P I E R

Public Interest Energy Research

CALIFORNIA ENERGY COMMISSION

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Executive Summary

PIER Program Background

In accordance with Public Resources Code Section 25620.8, the California Energy Commission has developed its third Annual Report to the Legislature concerning the Public Interest Energy Research (PIER) Program, for the period January 1 through December 31, 2000. Recent legislation across the nation shows that California's PIER Program is serving as a model for many other states. This Annual Report provides the following information: (1) a brief overview of the program including background information; (2) a current status of the program, including all funding awards made by the Commission as of December 31, 2000; and (3) the Commission's recommended future direction for the PIER Program.

Current Status of the PIER Program

Four major activities took place during 2000 and into early 2001. Contracts and grants continued to be awarded, but not at the pace the Commission hoped to achieve. A Five-Year Investment Plan was developed and transmitted to the Legislature on March 1, 2001. This plan was required under legislation (AB 995, SB 1194) signed into law in September 2000 that extended the Public Goods program to 2011.

An Independent Review Panel (IRP) was convened in late 1999. An interim report was issued in March 2000, and the final report was delivered to the legislature on March 20, 2001. Finally, based in part on the IRP's March 2000 recommendations, PIER was reorganized into its own division to reduce over-reliance on matrixed staff. This reorganization was announced, as part of a larger Energy Commission reorganization, on March 12, 2001.

The most important activity remaining is PIER's effectiveness in awarding contracts and grants to alleviate energy problems in California and to meet the overall objectives of the program.

PIER is organized into six program areas:

- Buildings and appliance energy efficiency
- Industrial, agricultural, and water energy efficiency
- Renewable energy technologies
- Environmentally-preferred advanced generation
- Energy-related environmental research
- Strategic energy research, including transmission and distribution and enabling technologies

During 2000, the Commission approved public interest energy research awards totaling approximately \$16.9 million through competitive awards, sole-source contracts, and interagency / intergovernmental agreements.

These awards will be matched with approximately \$44.3 million in other cash and in-kind matching funds, thus providing approximately \$61.2 million in total funding for these public interest energy research projects.

The funding and number of projects by program area are shown in Figure ES-1 below.

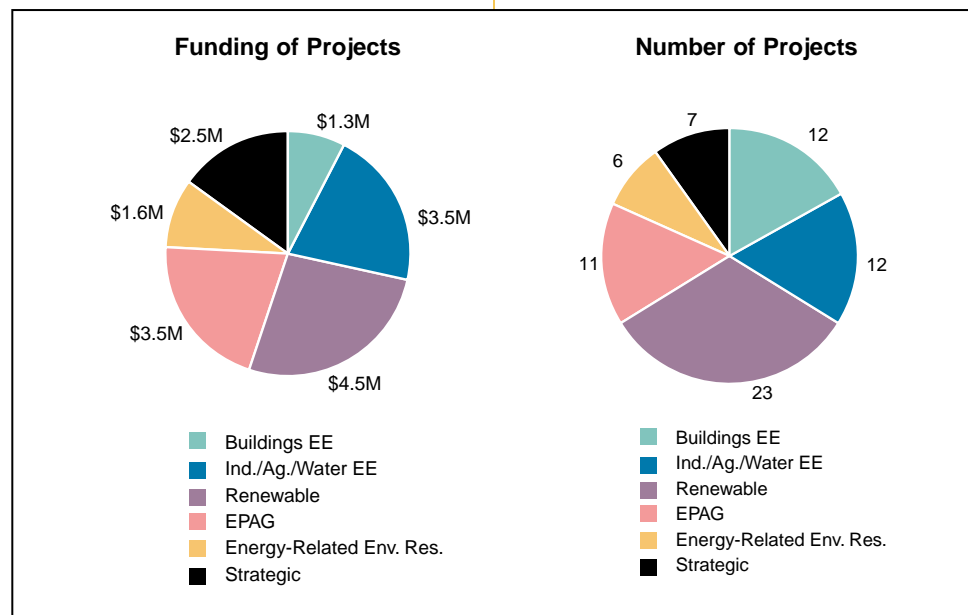


Figure ES-1. 2000 PIER Projects by Funding and Number of Projects

2000 PIER Program Successes

While still relatively early for positive research and development (R&D) results, some recent successes are described below:

In the area of **Buildings and Appliance Energy Efficiency**, researchers at the Department of Energy's Lawrence Berkeley National Laboratory (LBNL) have developed a new high-performance, energy-efficient table lamp that is designed to save energy in homes and offices while greatly increasing lighting quality and visibility. The widespread use of this lighting system in offices and homes could greatly reduce the current power problems that we have in California while increasing the quality of the lighting environment. At full power, this two-lamp fluorescent system matches the combined luminous output of a 300-watt halogen lamp and a 150-watt incandescent table lamp while using only a quarter of the energy.

In the area of **Industrial, Agricultural, and Water Energy Efficiency**, the PIER Program funded a project for a major Bay Area food processing facility which faced a potential environmental problem of wastewater disposal. A research, development, and demonstration project was sponsored by the PIER Program in collaboration with the California Institute for Food and Agriculture Research. The project tested and demonstrated the use of a new membrane that allows up to 80 percent of water recovery. When implemented,

the multiple benefits include an electrical load reduction of up to 250 kilowatts (kW), due to less need for fresh groundwater supplies and diminished environmental problems created by evaporating industrial wastewater on adjoining land.

In the **Renewable Energy** program area, the successful design, fabrication, and testing of the Wind Turbine Company's (WTC) 250 kW proof-of-concept (POC) prototype at the National Wind Technology Center in collaboration with the National Renewable Energy Laboratory (NREL) was completed. As a result of this



successful prototype, the Commission and WTC are moving on to field demonstration of a larger and pre-commercial 500 kW unit. The 500 kW unit will be demonstrated in conjunction with the Los Angeles Department of Water and Power (LADWP) at their host site. The purpose of the WTC project is to develop a lower-cost wind turbine system that can help make California's electricity more affordable. If successful, WTC's technology will lower the cost of wind-generated electricity in the near term to \$0.035 per kilowatt-hour.

In the **Environmentally-Preferred Advanced Generation** area, the PIER Program co-funded a project with the Gas Technology Institute (GTI) that will develop and demonstrate a natural gas reciprocating engine with high-efficiency, low initial cost, low operating cost (4 cents per kilowatt-hour), and low

emissions for the distributed generation market. Specifically, the project is developing and testing a MicroPilot injection system for installation on two Caterpillar diesel engines commonly used in gensets, so that they can run on natural gas. The results to date demonstrate a 50 percent reduction in oxides of nitrogen (NO_x) emissions to 2 grams per horsepower-hour and increased efficiency from 36 to 38 percent. The successful completion of the project will result in a system that can be mass produced and incorporated during manufacturing of new gensets or added as a retrofit to existing gensets.

The **Strategic Energy Research** program area is developing a technology in conjunction with San Diego Gas and Electric Company, and their sub-contractor, the Valley Group, to implement real-time transmission line ratings for a single site in San Diego. The results showed that at the tested location, real-time ratings indicated much higher power transfer capabilities than static ratings. This follow-on research will demonstrate the feasibility of implementing real-time transmission line ratings for Path 15, which is one of the most complex and critical gates in the California transmission system. The technical objective is to substantially increase the power transfer capability through Path 15. The economic performance objective is to decrease utility expenditures substantially through decreased transmission congestion on Path 15 during peak times.

PIER Program Administration

The final two activities were interrelated. The March 2000 IRP Interim Report provided the template for planning (as incorporated into the Five-Year

Investment Plan) and organization (as recently implemented).

Independent Review Panel Findings and the Commission Response

The PIER IRP found many valuable reasons to continue the program, but also made recommendations on how the program could be improved. The findings include the following:

- Energy-related issues are important enough in California to warrant a targeted, effective energy research, development, and demonstration (RD&D) program.
- The state has the intellectual resources and economic infrastructure to address those challenges through a well-managed, high-quality RD&D program.
- The importance of energy RD&D to California's continued economic growth, environmental performance, and science and technology leadership demands that the PIER Program be implemented effectively.

Despite myriad successes, the IRP found that PIER has suffered from a variety of problems—many administrative—that hamper its effective executions, including:

- The lack of a program director responsible for program planning and execution for most of the time since the inception of the program through March 2000
- A mismatch and lack of clarity between responsibilities, authority, and assets for managers
- Limited coordination among the Commission elements supporting the program

- An overly complex and time-consuming contracting process for PIER projects
- Unclear connections among other federal and private-sector energy RD&D activities, California's future energy-related needs, program goals, and public interest criteria

The IRP also believed that it was important to increase the autonomy and flexibility of the PIER Program within the Commission by raising the stature of the PIER Program, clearly defining the roles of the Commissioners, and vesting greater responsibility with the PIER Program.

Many of the leadership and management issues that the IRP raised in March 2000 have been resolved and their recommendations put into effect. The development of the PIER Five-Year Investment Plan focused on policy and planning. A vision has been developed consistent with the PIER Program's mission and California's needs. The operational definition of public interest criteria has been clarified. The Commission's work has better defined the program context in terms of state problems and current state, federal, and private activities. Problem areas have been identified, and a set of focused strategies have been developed to address them. Road maps will be developed for measuring success with predefined metrics.

While some progress in contract reform has occurred, problems within the Commission remain. A more streamlined approach to contracting and Request for Proposal development is underway. The Commission is looking for ways to expedite the execution of agreements.

State-mandated limitations on the Commission's procedures may necessitate external changes.

Staffing remains a major internal problem. The lack of staff has caused the PIER Program to fall behind schedule in project funding. The inability to create new positions and the lack of opportunities for existing staff decreases the Commission's capacity to attract and retain high-caliber staff. PIER has consolidated its operations within an independent division led by the PIER Program Manager to allow better operational control with less reliance on matrixed staff. Some legislative relief may be necessary in both the administrative and staffing areas.

PIER is using innovative approaches to solve staff issues. The Commission made use of the Interagency Jurisdictional Exchange mechanism to bring in the Program Manager and is exploring using this mechanism to acquire new staff from the University of California. The Commission intends to make greater use of technical support contractors, as well as obtain broader support from key research and development contractors. The use of technical advisory panels will be expanded in all subject areas. The goal is to reach an intellectual and operational critical mass for the PIER Program, which it is currently lacking.

PIER Five-Year Investment Plan

PIER management intends to move forward to address and solve problems identified in the Five-Year Investment Plan. These problems are described below:

Electricity demand has been increasing faster than supply. The PIER Program will address this problem by funding RD&D aimed at:

- Increasing electricity supply
- Reducing electricity demand
- Developing better information and decision-making tools

Rising peak demand threatens reliability and power quality. The PIER Program will address the problem of rising peak demand by funding RD&D aimed at:

- Increasing local generation technology options
- Reducing and shifting peak demand to off-peak periods
- Enhancing the performance of transmission and distribution systems

Balance is needed between energy needs and environmental protection. The PIER Program will address the problem by funding RD&D aimed at:

- Improving the prediction, measurement, and mitigation strategies of environmental impacts from electricity systems
- Developing electrical technologies that benefit the environment

Market uncertainty and price volatility are impacting energy delivery and use. The PIER Program will address this problem by funding RD&D aimed at:

- Improving the understanding of California's energy market structure and rules

The PIER Program has adopted a portfolio and budgeting approach to effectively balance the risks, benefits to ratepayers, and time horizons for various PIER activities and investments. In addition, the program will continue to establish various linkages with other energy RD&D institutions with whose collaboration the program will be able to multiply its own effectiveness.

The design of the PIER Portfolio will meet the following criteria:

- Apply an integrated set of technology RD&D strategies to California's energy problems
- Address different time frames for impact on the market and different challenges along the RD&D spectrum
- Fund integrated solutions for major energy problems
- Provide for market connectedness.

The PIER Program Five-Year Investment budget must balance the competing objectives of addressing the four major energy problems facing California, maintaining flexibility to respond to the unpredictable changes that are likely to occur, and adhering to the criteria described above. These will be accomplished by (1) dedicating a minimum of \$165 million (approximately one-half of the funds available over the five years) to implementing the various strategies, which are designed to address the four problems shown in Table ES-1; and (2) reserving the remaining available funds (approximately \$147.6 million over five years) to be competitively allocated to

specific activities and strategies based on their expected public interest benefits.

Funds will be allocated based on the road maps to be developed for each subject area and on overall program goals. These road maps will contain criteria for project selection and a set of metrics to gauge project and program impacts. The Program Manager will retain funds that will be allocated to subject areas as new opportunities are identified.

Table ES-1. PIER Program Budget for 2002 through 2006

Electricity Problems of Highest Concern in California	Five-Year Budget (\$ million)
1. Electric demand is increasing faster than supply.	\$50.0
2. Rising peak demand threatens reliability and power quality.	\$50.0
3. Balance is needed between energy needs and environmental protection.	\$50.0
4. The market protection uncertainty and price volatility are impacting energy delivery and use.	\$15.0
Dedicated five-year competitive budget	\$165.0
Reserved five-year competitive budget	\$147.6
Total five-year budget at \$62.5 million per year	\$312.5



P I E R

Public Interest Energy Research

CALIFORNIA ENERGY COMMISSION

I. Overview of the PIER Program

A. Background

In 1996, California adopted far-reaching legislation that deregulated much of the state's electric services industry (1996 Statutes, Chapter 854, hereinafter referred to as AB 1890). Article 7 of AB 1890 was enacted to ensure that the benefits obtained from important public purpose programs—such as public interest energy research, development, and demonstration (RD&D)—would not be lost in the newly deregulated environment. As a result, Public Utilities Code Section 381 requires that, starting on January 1, 1998, and extending through 2001, at least \$62.5 million be collected annually through California's electric investor-owned utilities (IOUs) to fund energy-related public interest RD&D activities “not adequately addressed by competitive and regulated markets.” In September of 2000, the legislature passed and Governor Gray Davis signed into law SB 1194 (Sher) and AB 995 (Wright)

extending the PIER Program surcharge for an additional 10 years from January 2001 to January 2012.

The California Energy Commission (the Commission) is authorized in AB 1890 to receive and administer such funds as designated by the California Public Utilities Commission (CPUC) for the conduct of public interest RD&D, subject to administration and expenditure criteria established by the Legislature. In 1997, the CPUC determined that at least \$61.8 million annually should be transferred from the major IOUs to the Commission for specified public interest energy research (D.97-02-014)¹. These funds are subject to the administrative and expenditure criteria adopted by the Legislature in 1997 (1997 Statutes, Chapter 905, hereinafter SB 90), which are contained in Public Resources Code Section 25620 et seq.

¹ In 1998, a small IOU, Bear Valley Electric Company (also known as Southern California Water Company), sought and received CPUC authority to contribute \$56,000 annually to the PIER Program.

B. Five-Year Investment Plan

Beginning in 1996, the Commission conducted an extensive public process resulting in a report entitled Strategic Plan for Implementing the RD&D Provisions of AB 1890, (P 500-97-007, June 1997). This report included a mission statement and objectives for the PIER Program, as well as a strategic plan for administering the program through the first four years.

SB 1194 and AB 995, enacted in 2000, require the Commission to file with the Legislature by March 1, 2001, a five-year “investment plan” report addressing how the Commission will manage the PIER Program from 2002 through 2006 and respond to issues raised by the PIER Independent Review Panel (IRP). The Five-Year Investment Plan encompasses the following:

- Fundamental mission, objectives, and vision for implementing the PIER Program
- Operational definition of public interest energy research
- Description of the “California Energy Context” (an example is shown in Figure 1) including demographics, high-technology sector, social values, air quality, water, and global climate change
- Energy-related impacts to which this context will give rise in the future
- RD&D strategies and activities to address California’s energy problems
- Budget strategy and proposed budget for the PIER Program
- Steps the Commission has taken and will take to address the concerns of the PIER IRP

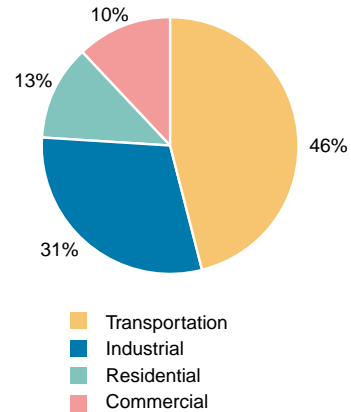


Figure 1. California Energy Context – Energy Use by Sector

Note: Data based on 1996 information produced in 1998.

C. PIER Vision

In the future, California must provide a clean, affordable, reliable, and resilient supply of electricity where “smart,” efficient customers have energy choices that can meet their individual needs, and California’s industries can grow and prosper. The PIER Program will support and catalyze science and technology advancements by providing leveraged funding to establish California as the world leader in energy efficiency and clean, advanced energy technologies and systems.

D. PIER Mission

The mission of the PIER Program is to conduct public interest energy research that seeks to improve the quality of life for California citizens by developing environmentally sound, safe, reliable, and affordable electricity services and products. Public interest energy research includes the full range of RD&D activities that advance science and technology not adequately provided by competitive and regulated markets.

E. PIER Program Objectives

Based on the goals set forth in the PIER Program's mission and vision, the Commission also adopted specific objectives for the PIER Program, updated in the Five-Year Investment Plan. These objectives are to advance science or technology to achieve the public benefits of:

- Improving energy cost/value
- Improving the environment, public health and safety
- Improving electricity reliability/quality/sufficiency
- Strengthening the California economy
- Providing greater choices for California consumers

F. PIER Program RD&D Areas

The subject areas for the PIER Program are defined in SB 90:

The program shall consist of a balanced portfolio that addresses California's energy and environmental needs, technology opportunities, and system reliability. To achieve balance, the Commission shall actively solicit applications for the under-represented subject areas of end-use energy efficiency, renewable technologies, and environmental enhancements. The portfolio shall include the relevant core subject areas of environmental enhancements, end-use efficiency, environmentally-preferred advanced generation, renewable technologies, and other strategic energy research, including public interest system reliability research, demonstration, and development not adequately addressed by the Public Utilities Commission (PUC).

The Commission's RD&D Strategic Plan recommends that planning efforts for the PIER Program be undertaken at levels corresponding to the program's organizational structure and funding areas. In 1998, the Commission established the following six PIER Program funding areas:

- Residential and Commercial Buildings End-Use Energy Efficiency
- Industrial / Agricultural / Water End-Use Energy Efficiency (Process Energy)
- Renewable Energy Technologies
- Environmentally Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research

The PIER Program Manager has clear authority to make decisions regarding the PIER Program. Six teams are led by staff experts called Team Leads, who report to the PIER Program Manager. The teams are segregated by each of the six program areas listed above. Each team is responsible for planning and implementing the RD&D activities needed to meet specific PIER goals and deliver results in the program areas in question. As with all aspects of the PIER Program, this effort is conducted with review and input from the Policy Advisory Council (PAC), focus groups, stakeholders, and interested members of the public. Current and future program plans will be periodically reviewed and evaluated—both internally and externally—to recognize the changing roles and scope of the program.

G. Energy Innovations Small Grant Program

The Energy Innovations Small Grant (EISG) Program is an integral part of the PIER Program that offers grant funding up to \$75,000 to small businesses, nonprofits, individuals, and academic institutions to conduct proof-of-concept (POC) research to establish the feasibility of new innovative solutions to California's energy problems. The EISG program seeks to assist the development of technologies that are not already adequately funded through the competitive and regulated markets. Up to four solicitations per year are conducted with each solicitation open to all six PIER Program areas. To encourage participation in the program the application and award process is more simplified and streamlined than other programs administered by the Commission.

The EISG program is managed by the Commission with program administration outsourced to California State University. The program is funded at \$2.5 million/year with \$2 million allocated to grants and \$.5 million for program administration. The EISG program has awarded 54 grants valued at \$4.03 million since the program started in September 1998.

II. Current Status of the PIER Program

The current status of the various functions of the PIER Program, as of December 31, 2000, is set forth below.

A. PIER Five-Year Investment Plan (The “California Context” and the problems identified in the Five-Year Plan)

AB 1890, SB 90, AB 995, and SB 1194, the Commission’s RD&D Strategic Plan, and the Five-Year Investment Plan have identified the essential state policies for energy-related public interest research that are to be carried out through the PIER Program. In turn, the results from the PIER Program are expected to provide input for future state energy policies.

In addition, PAC provides ongoing advice to the Commission’s RD&D Committee regarding the effective implementation of the PIER Program. The Policy Advisory Council (PAC) is comprised of a group of high-level representatives from industry, academia, research institutions, and various stakeholder associations. A list of the members of the PAC is included in Attachment 2.

The advancement of science and technology through the PIER Program can provide lasting technological solutions to mitigate California’s energy problems, particularly if the research is directed at meeting California’s specific needs. California is faced with many energy-related challenges from circumstances and trends that include demographics, technological advances, economic conditions, social values, political factors, and climate and environment. Establishing this California energy context for the PIER Program is a major component of the Five-Year Investment Plan. As an example of the Commission’s efforts to establish the California context, Figure 2 shows the trends in cost of purchased power.

Another primary function of the Five-Year Investment Plan was to identify California’s energy problems and propose solutions. The identified problems are listed below:

- Electricity demand has been increasing faster than supply.

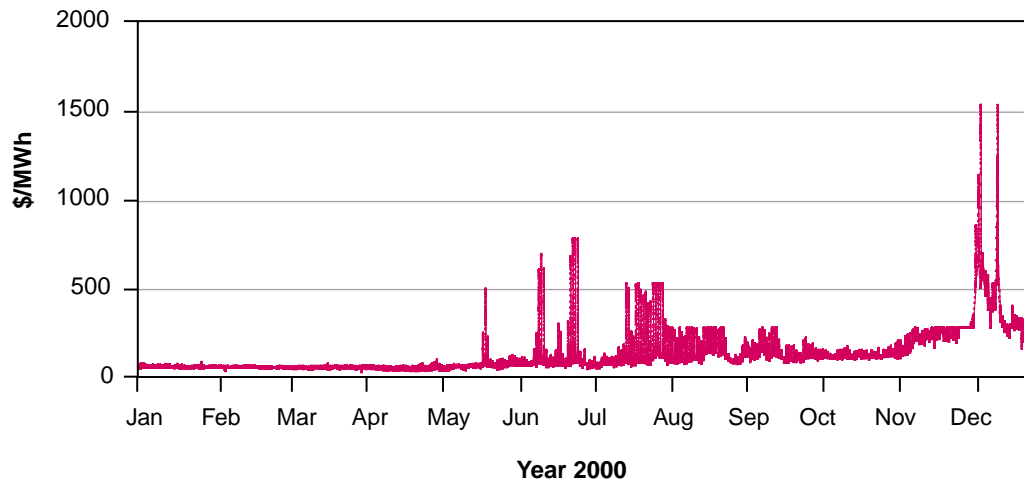


Figure 2. Trends in Cost of Purchased Power

- Rising peak demand threatens reliability and power quality.
- Balance is needed between meeting energy needs and environmental protection.
- Market uncertainty and price volatility are impacting energy delivery and use.

B. PIER Program Success Stories

The PIER Program conducts public interest energy research to find ways to improve the quality of life for California's citizens. Five overall objectives of PIER project funding were developed and followed during the initial four-year transition period as identified below:

1. Improve energy cost/value of California's electricity system.
2. Improve environmental and public health costs/risk from California's electricity system.
3. Improve reliability/quality of California's electricity system.
4. Improve safety of California's electricity system.

5. Maximize market/economy connection.

The number of projects addressing these objectives are shown in Figure 3.

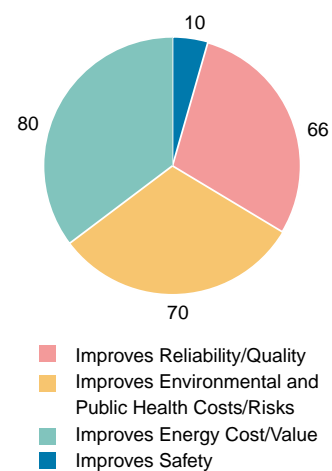


Figure 3. Number of Projects Addressing the PIER Program Funding Objectives*

* Based on all projects funded in 1998–2000, excluding projects from the Energy Innovations Small Grant Program

Note: All selected projects address the PIER Program objective of maximizing market/economy penetration.

The Five-Year Investment Plan will meet these objectives by allocating funds for the following:

- Advancing science and engineering for a diverse range of technologies
- Addressing different time frames for impact on the market and different challenges along the RD&D spectrum
- Funding integrated solutions for major energy problems
- Funding technology partnerships to leverage PIER funding

The overall PIER funding objectives are implemented by selecting and supporting projects in the following six PIER Program areas (listed with their public benefits) and the EISG:

Residential and Commercial

Buildings End-Use Energy Efficiency: Decreasing building energy use through research that will develop and improve building energy technologies, practices, strategies, and tools and improve building performance evaluation methods

Industrial/Agricultural/Water End-Use Energy Efficiency: Increasing energy efficiency of industrial processes, water and wastewater treatments, and agricultural operations to cost-effectively mitigate environmental problems, waste treatment needs, and the challenges presented by the deregulated energy markets

Renewable Energy Technologies: Increasing energy diversity and affordability, using renewable energy strategically to help improve the reliability and responsiveness of California's electricity system, improving environmental quality, enhancing management of natural

resources, and developing local and state economies

Environmentally Preferred Advanced Generation: Increasing cost savings and generation choice for energy consumers, improving environmental quality, and reducing fuel consumption

Energy-Related Environmental Research: Improving scientific understanding and/or addressing the environmental effects and costs of energy production, delivery, and use in California and exploring how new energy services and products can solve environmental problems

Strategic Energy Research: Conducting research to improve electric system reliability, efficiency, affordability, and environmental health and safety and developing technologies that give Californians improved and customized electricity services

Critical public interest issues and technical goals and objectives have been identified for each program area. These issues and goals are used as guides in selecting projects that are most likely to create the above stated public benefits. Summaries of the program area issues, as well as realized and expected public benefits, are presented below.

Residential and Commercial Buildings End-Use Energy Efficiency Successes and Outlooks

The buildings program area includes new and existing buildings in both the residential and nonresidential sectors. The program seeks to decrease building energy use through research that will develop and improve building energy technologies, practices, strategies, and tools and improve building performance

evaluation methods. In 1999, a final draft of a buildings program area plan was developed; it identified program issues and goals as well as strategies for meeting these goals. Four major issues motivating energy efficiency RD&D for California buildings have been identified:

1. Energy consumption is increasing in hotter, inland areas as new building construction increases in these areas.
2. Current development of energy-efficient products and services does not adequately consider non-energy benefits such as comfort, productivity, durability, and decreased maintenance.
3. Building design, construction, and operation of energy features can affect public health and safety.
4. Investment in energy efficiency affects building and housing affordability and value, and the state's economy.

Success Story: One example of a PIER transition contract that has been completed and is successfully moving forward into the marketplace is a multifunctional high-efficiency table lamp.

Researchers at the Department of Energy's Lawrence Berkeley National Laboratory (LBNL) have developed a new high-performance, energy-efficient table lamp that is designed to save energy in homes and offices while greatly increasing lighting quality and visibility.

Widespread use of this lighting system in offices and homes could greatly reduce the current power problems we have in California while increasing the quality of the lighting environment. Nothing currently available in the

office, hospitality, or residential marketplace has both the high-performance lighting quality characteristics and energy efficiency of this new lamp. At full power, this two-lamp fluorescent system matches the combined luminous output of a 300-watt halogen lamp and a 150-watt incandescent table lamp while using only a quarter of the energy.



LBNL is working with the Commission, Sacramento Municipal Utility District (SMUD), Southern California Edison (SCE), and Pacific Gas and Electric (PG&E), to acquire and field-test the first production lamps based on the new high-performance design.

The new lamp uses two independently controllable and fully dimmable compact fluorescent lamps (CFLs). One lamp's light is directed downward, illuminating the table or desk. The other directs light up toward the ceiling, providing high-quality indirect lighting. An optical "septum" separates the two lamps, allowing three modes of lighting: downward only, upward only, or up and down together. The relationships between the lamps, the septum, and the lamp shade have been designed to maximize the efficient

distribution of light as well as to provide soft and even shade brightness.

This lamp is clearly an energy saver in homes, but it is also a great energy-efficient alternative in office spaces. Substantial savings can be had by turning off overhead room lighting altogether and using this lamp. The “down” light gives the user more than enough flux (light output) for most tasks, while the “up” light provides a low-glare ambient light that is ideal for computer environments.

Examples of public benefits

anticipated in 2001: In 2000, the PIER buildings team conducted an extensive analysis of the buildings research portfolio currently funded under PIER and identified several areas of needed research. From this portfolio analysis, the team identified the need for additional research applicable to existing residential buildings with a specific focus on water heating and envelope technologies that provide both energy efficiency and comfort. Research responsive to low-income and multi-family housing was specifically encouraged as was research responsive to construction-related actions that could lead to more energy-efficient residences. Based on early indicators of success using the programmatic approach, a targeted, programmatic solicitation was issued on July 14, 2000. As a result of this solicitation, the team is proposing to fund three contracts in the following areas:

Energy-Efficient Low-Income Housing:

This research program will address ways of improving energy efficiency and comfort in low-income households. Low-income households incur relatively greater energy expenses as a percentage

of income and are, therefore, particularly burdened by rising energy costs. This contract will identify, develop, and evaluate low-cost strategies and technologies for improving energy efficiency in low-income households. The research will involve installing and monitoring simple energy-efficient options for space conditioning and building envelope technologies.

Profitability, Quality, and Risk Reduction Through Energy Efficiency: This research program will address needed changes in builder practice in California to ensure quality, comfortable, energy-efficient single family new homes through the development of new design manuals for envelope and heating, ventilation, and air conditioning (HVAC) systems; a new rating system that measures quality, comfort, and energy efficiency; and new mortgage products. The research team includes an unprecedented collaboration between the Building Industry Institute, the National Association of Home Builders Research Center, a homebuyers warranty company, a national secondary lender, and production builders.

Synergistic Water Heating and Distribution Technologies: This research program will identify and develop technologies that enable the efficient generation and distribution of hot water. Included in this program are the development of a combined refrigerator/ electric hot water heater, an enhanced heat pump water heater, and an analysis of more efficient distribution systems. Industry manufacturing partners are included in all phases of the proposed research, ensuring a market pathway for the research products at the end of the development phase.

Industrial/Agricultural/Water End-Use Energy Efficiency Successes and Outlooks

Industrial, agricultural, and water sectors in California use 30 percent of all the electricity consumed in the state. These sectors are critical to California's economy and rely on an affordable, reliable, and sustained supply of energy in general and electricity in particular. Through RD&D, the program seeks to improve the energy efficiency of the industrial processes, agricultural operations, and water and wastewater treatment plants. Since these sectors are also sensitive to power quality and reliability of the electric supply. The program also strives to research, develop, and demonstrate technologies to help in these areas. Following are the specific RD&D priorities for the coming year in industrial, agricultural, and water sectors.

Industry: California's large industrial base includes the highest concentration of some of this nation's industries. The energy reliability of these industries is critical not only for California's economy but for the national economy as well. The major industries, such as food processing, electronics and e-commerce, petroleum, and chemicals, all depend on continued low energy costs and reliability. PIER has analyzed the energy needs of several of these industries and for the coming year will work in collaboration with some of them to identify RD&D options to specifically overcome their energy-related problems. PIER will focus on RD&D activities that will provide them with the agility to meet the recent energy crisis. Industry is often required to maintain low manufacturing costs while maintaining environmentally

clean and energy-efficient operations. The PIER Program will focus its research on activities that will help industry attain this difficult yet critical balance.

Water: The availability of low-cost, clean water is essential to California's economy and continued prosperity. The state depends heavily upon the transportation of a large volume of water across the state and also upon the treatment of substandard and saline water in large quantities. RD&D activities that help improve the energy-efficiency of processing water for urban, industrial, and agricultural consumption and an energy efficient treatment of wastewater recovery will remain the focus of this program area. The program will continue to manage the current contracts with the consortium of water utilities and work with them for a wider adoption of the technologies developed through these projects.

Agriculture: Agriculture forms a large segment of California's economy, exports, and employment. Agriculture is very much dependent upon electrical energy for irrigation and post-harvest processing. Electrical costs and reliability are critical for a successful and sustainable agricultural operation. The PIER Program will continue its RD&D activities in the techniques for advanced irrigation and other load management practices that will help this sector cope better in the restructured electrical market. The program will continue to manage currently funded projects in the area of advanced irrigation practices for water conservation and water recovery.

Success Stories: Some of the projects undertaken by PIER's industrial, agricultural, and water sectors energy

efficiency programs in the year 2000 are indicative of the work done to help these sectors meet the challenges and attain public benefit objectives of the program.

A major food processing facility in the Bay Area faced a potential environmental problem of wastewater disposal. Replacing the wastewater with fresh water from underground reservoirs also required electricity use that was becoming increasingly expensive and unreliable. An RD&D project was sponsored by the PIER Program in collaboration with the California Institute for Food and Agriculture Research. The project tested and demonstrated the use of a new membrane that allows for up to 80 percent of water recovery. When implemented, the project would reduce the electrical load by 250 kilowatts (kW), minimize depletion of underground freshwater reservoir and eliminate the environmental problem caused by spreading of industrial wastewater on adjoining land in a semi-urban area. The Bay Area, which faces some of the most severe electrical supply challenges in California, could reduce a substantial load from its grid by implementing these changes.

The use of methyl tertiary-butyl ether (MTBE) as a gasoline additive generated a groundwater contamination problem in California. The primary source of contamination is leaking underground fuel tanks (LUFTs). There are thousands of such sites in California, some resulting in nearby groundwater concentrations of MTBE as high as 6,000,000 parts per billion (ppb). Groundwater MTBE migrated from LUFTs to drinking water supplies. The current maximum contaminant level of MTBE in drinking water ranges from

5 ppb (recommended) to 13 ppb (acceptable).

In addition to the currently investigated technologies for removal and/or destruction of MTBE in groundwater, such as oxidation, air stripping, and activated carbon absorption, membranes could provide an effective and energy-efficient means of treatment. The key issue is clearly that of economics: the process has to be cost-effective, as well as practical on a large scale. A recent advancement in membrane technology, called supported polymeric liquid membranes (SPLM), introduces great flexibility in significantly enhancing membrane transport rates, thus driving the cost down substantially. SPLM technology couples the best membrane support structure (porosity, pore size, and thickness) with an optimum polymeric liquid and controlled coating technology. Such membranes are much more energy efficient than traditional membranes used for reverse osmosis.

Research sponsored by the PIER Program and the Electric Power Research Institute (EPRI) has proven the technical merits of SPLM technology for MTBE mitigation, and efforts are underway to scale up the process for demonstration and subsequent commercialization. The public benefit lies in restoring water quality while using substantially lower energy than other traditional technologies.

Renewable Energy Technologies Successes and Outlooks

California's electricity system underwent dramatic changes in the latter part of 1999 and early 2000. Natural gas prices—expected to remain low—rose rapidly and by as much as 300 percent. In addition, unanticipated increases in

localized electricity demands coupled with slower than expected growth in generating capacity resulted in very high and volatile electricity prices, a record number of stage two electricity alerts, and rolling blackouts. As a consequence, California's renewable energy industry found itself in a far different situation than it faced leading into 1999. Instead of struggling to compete in a competitive deregulated electricity market, renewable generators suddenly faced requests to rapidly accelerate deployment of new renewable capacity and restore facilities that had been closed due to poor economics. Increased demands for new renewable capacity and higher electricity prices have been a boon to California's renewable industry. However, few within the industry expect the electricity crisis to extend far into the future. Most industry participants believe increases in generating capacity will force wholesale electricity prices back down within the next two to three years, although at levels above the early 1999 wholesale prices. Consequently, many of the issues that faced the industry leading into 2000 will resurface as California's electricity crisis is resolved, and some have been exacerbated because of the nature of the crisis. Among the critical issues facing renewable energy development in California are the following:

- In the near term, there is increasing pressure to deploy renewable energy facilities to help add generating capacity, improve system reliability, and help stabilize California's electricity prices. However, such strategic application of renewables is hindered by lack of understanding on how best to integrate renewables into the existing system, to integrate

appropriate renewable energy configurations, and to integrate the control logic and hardware needed to ensure system stability and safety.

- In the longer term, a sustainable development of renewable energy that provides high value to California's electricity system requires renewable electricity generation systems with improved dispatchability and increased ancillary services capabilities. To a large extent, this development pathway will be tied to growth in renewable distributed generation systems. This growth requires additional understanding and demonstrations of renewable distributed generation systems used in combination with fossil-based generation and configured to meet a variety of electricity customer classes or electricity system sub-regions.
- California's electricity problems have emphasized the need for renewables to provide increased value to the electricity system. However, it is equally important that renewables be developed in a manner that provides environmental benefits to the state. As a result, renewable electricity technologies must improve their ability to surpass environmental regulations and make better use of renewable resources that currently pose environmental concerns (e.g., increased use of agricultural residues that are currently burned in the field, increased use of forest materials that pose high wildfire risks, etc.)

PIER RD&D efforts in the renewable energy area have focused on three objectives: 1) making improvements at existing renewable energy facilities to help provide peak capacity and increased reliability to California's

electricity system; 2) expanding renewable distributed generation technologies to help provide electricity generation in high-demand, high-congestion areas; and 3) developing renewable energy technologies, products, and services for tomorrow's electricity system to provide electricity customers with more affordable electricity, improved reliability, and a selection of choices. To accomplish these objectives, the PIER renewables group is working collaboratively with private industry, the national laboratories, not-for-profit research entities, and academic institutions.

Among the accomplishments in the past year are the following:

- Successful design, fabrication, and testing of the Wind Turbine Company's (WTC) 250 kW proof-of-concept (POC) prototype at the National Wind Technology Center. As a result of a successful prototype, the Commission and WTC are moving on to field demonstration of a larger and pre-commercial 500 kW unit. The 500 kW unit will be demonstrated in conjunction with Los Angeles Department of Water and Power (LADWP) at an LADWP host wind site. The purpose of the WTC project is to develop a lower-cost wind turbine system that can help renewable energy make California's electricity more affordable. If successful, WTC's technology will lower the cost of wind-generated electricity in the near term to \$0.035 per kilowatt-hour.
- PIER renewables funding was provided to PowerLight Corporation for support in developing innovative ways to reduce the cost of manufacturing building-integrated

photovoltaic (PV) modules as electricity-producing roofing tiles. As a result, PowerLight achieved a 57 percent reduction in the cost of manufacturing its PowerGuard PV tile and opened an automated tile manufacturing facility in Berkeley with a production capacity in excess of 16 megawatts (MW) per year of PowerGuard tiles. The overall goal of the PowerLight project is to help provide California's electricity customers with a renewable energy option to help meet their electricity needs. The PowerLight approach has the added benefits of providing customers with a roofing system that is durable and long-lived, and reduces heat gain in buildings due to its increased insulating value.

- California has 600 MW of biomass-fueled power plants that can provide valuable additional capacity to the state's strained electricity system. However, due to their solid fuel characteristics, biomass power plants typically cannot make rapid changes in the amount of electricity they generate. Consequently, they have traditionally not been able to provide peak generating capacity to the electricity system. Through PIER renewables funding support, the Gas Technology Institute (GTI) has been developing co-firing of biomass boilers with natural gas using NO_x gas burner technology. Co-firing will provide biomass power plants faster load responsiveness, faster startup, and the ability to provide some of their capacity in the form of peak generation. Prototype low-NO_x co-firing systems have been successfully designed, built, and installed in two biomass power plants in California. Testing of the systems has been

delayed due to increased pressure on the plants to maximize their operating hours, but testing is expected to begin by summer of 2001.

- Development of renewable distributed generation technologies that also provide environmental benefits to California is important in establishing a diversified, responsive, and environmentally constructive electricity system. Community Power Corporation (CPC) received PIER renewables funding to develop a small modular biopower system capable of providing either remote or grid-tied electricity via a distributed generation mode. Within the CPC project, a 12 kW system is to be demonstrated using forest thinnings collected by the Hoopa Valley Tribe. Electricity and heat generated from the biopower distributed generation system will be used to offset electricity and energy demands in the Tsemata Forest Regeneration Complex while avoiding the current practice of pile burning the thinnings. CPC has successfully completed shakedown testing of its prototype system and has finished preliminary layout of the small modular biopower system at the Forest Regeneration Complex. The field unit is expected to be installed at the Hoopa Valley Tribe site in fall of 2001. If successful, the CPC project will demonstrate the ability to use forest thinnings in a forest-urban interface area to help meet electricity system needs while simultaneously reducing wildfire risks. This project may also act as a model approach that could be used to help resolve wildfire threats in environmentally pristine areas such as the Lake Tahoe Basin.

Outlook: To date, approximately \$15 million in PIER funds have been directed in the renewables RD&D area. Outcomes expected in 2001 include:

- Field testing of an extended induction logging tool being developed by ElectroMagnetic Instruments, Inc. that will significantly help in managing existing geothermal reservoirs and reduce the costs associated with geothermal exploration and extraction. Presently, exploration accounts for nearly 40 percent of the cost of harnessing geothermal energy.
- Completion of bench-scale and field tests on using biomass residues to produce both electricity and ethanol at the Collins Pine Biomass Cogeneration facility. Successful development of such co-located facilities can help make electricity more affordable by the development of non-energy related revenue streams. In addition, with the Governor's Executive Order in March of 1999 mandating the phaseout of MTBE from gasoline sold in California by 2002, there will be an increasing demand for ethanol as a fuel oxygenate. Co-located facilities such as Collins Pine potentially offer California the ability to develop ethanol supplies from indigenous resources rather than purchasing them from the Midwest.
- Field testing of a low-head, low-impact hydroelectric system being developed by PowerWheel. This system can potentially be installed in thousands of irrigation canals located in California, thereby increasing the use of small hydroelectric resources for distributed generation purposes. Field tests will focus on determining

the costs and reliability of the low-head hydroelectric system.

- Completion of an advanced rooftop PV, power conditioning, and battery storage system being developed by Utility Power Group to help provide lower-cost PV systems to residential electricity customers and supply them with a short-term electricity supply in the event of rolling blackouts. The system will reduce the installed cost of grid-connected PV systems by over 30 percent and increase reliability of the systems by a factor of five.

Environmentally Preferred Advanced Generation Successes and Outlooks

The electricity supply situation in California and the growth of e-commerce have created the need for high power quality and high reliability (expressed as “six nines” or 99.9999 percent availability). Increasingly high levels of availability cannot be provided by the utility grid. Backup generation, usually provided by diesel engines, has been a solution to occasional electricity supply disruptions. With the threats of high and blackouts, on-site generation—distributed generation (DG)—is being sought in many situations as the routine source of electrical energy, not just the emergency response.

However, the routine use of diesel engines is limited by California’s air pollution rules. Cleaner generating technologies are evolving and are at various stages of development, but are not yet competitive. In a restructured electricity market, continued development of these emerging technologies to provide lower installed costs and improve performance holds

the promise of improved air quality, reduced cost of electricity, dispatchability, high reliability, and high power quality.

DG refers to locating small-scale, stationary, electric generating systems close to their loads. By being located close to load centers, DG improves efficiency by avoiding transmission and distribution losses (approximately 10 percent) and congestion. It also postpones or eliminates the need for new or expanded transmission and distribution facilities, thereby avoiding the capital costs and environmental impacts of these facilities. Furthermore, waste heat produced by some DG technologies can be used on-site for co-generation or combined heat and power (CHP) applications. Waste heat utilization can raise the First Law of Thermodynamics efficiency to 80 percent. With these benefits, DG efficiencies compete very well with those of the newest natural gas combined cycle central station power plants.

Distributed power units include generating technologies such as diesel engines, small and “micro” gas turbines, fuel cells, solar photovoltaics, and wind turbines; and may be combined with electric storage technologies such as batteries and flywheels. The Environmentally-Preferred Advanced Generation (EPAG) unit of the PIER Program has the objective of facilitating widespread use of non-renewable DG and improving California’s air quality by developing reliable, inexpensive emission reduction technologies for internal combustion engines, small turbines and micro-turbines, fuel cells, and hybrid fuel cell-microturbine technologies. DG is the application by which the EPAG program will provide tangible public

benefits in the form of clean and reliable on-site electricity generation.

The EPAG strategy is to develop technologies that provide these public benefits over a range of timeframes—short-term, mid-term, and long-term. This will help ensure a continued reduction of emissions while improving overall system reliability as improved EPAG technologies are applied to DG applications. In the near-term, this means reducing the emissions of reciprocating engines used as backup generators. In the mid-term it means reducing the emissions and cost while improving the performance characteristics of small turbine and microturbine generators (MTGs), which are already significantly cleaner than diesel engines. In the long-term the goal is to develop cost-competitive and innovative technologies such as fuel cells and hybrids, which are exceptionally clean but currently unproven and very expensive.

Near-Term Benefits: Motor-generator sets using reciprocating engines are the most mature type of DG. They have been used extensively for standby and emergency power, and are currently being installed by companies fearing blackouts and power quality problems resulting from California's current electricity crisis. However, these diesel-powered units are limited to short duty cycles because of significant emissions of NO_x and particulates. EPAG projects are addressing this problem.

For example, a PIER co-funded project with GTI will develop and demonstrate a natural gas reciprocating engine with high-efficiency, low initial cost, low operating cost, and low emissions for the DG market. Specifically, the project is developing and testing a MicroPilot

injection system for installation on two Caterpillar diesel engines commonly used in gensets, so that they can run on natural gas. Results to date indicate a 50 percent reduction in NO_x emissions to 2 grams per horsepower-hour and increased efficiency from 36 to 38 percent will be achieved. The successful completion of the project will result in a system that can be mass produced and incorporated during manufacturing of new gensets, or added as a retrofit to existing gensets.

Mid-Term Benefits: For EPAG's mid-term time horizon, PIER is funding projects to reduce the emissions and costs of small and micro-scale gas turbines. Currently, many gas turbines that could be beneficial in DG applications are not able to comply with air quality regulations because of the high cost of exhaust cleanup systems. Here the EPAG strategy is to develop efficient, low-cost combustion technologies that prevent the formation of pollutants, rather than use post-combustion cleanup. In a previous PIER contract with Alzeta Corporation, the company designed, built, and tested a prototype combustor for MTGs that produces ultra-low levels of NO_x emissions. This work is being continued in a new follow-on contract to test the combustor in an operating MTG and to develop prototype combustors for industrial-scale engines. Alzeta and its industrial partners will develop manufacturing methods that eliminate welding in the fabrication of the combustor, which will reduce the cost of manufacturing and increase the life of the combustor. This will enable cost-effective reduction of NO_x emissions for even the smallest MTGs. Goals of the project are to (1) simultaneously reduce NO_x and CO emission to less

than 2 parts per minute without any post combustion exhaust cleanup, (2) design a combustor with a cost on par with original equipment combustors, and (3) eliminate the need for expensive, selective catalytic reduction (SCR).

EPAG has a similar research effort with Catalytica Combustion Systems, Inc., to greatly reduce the formation of NO_x in industrial and larger-size gas turbines. With EPAG funding during 2000, Catalytica has developed a catalytic combustor for industrial scale turbines. To date this technology has been tested on a 1.5 MW industrial gas turbine for 8,000 hours with NO_x emissions less than 2 ppm and no degradation in performance. The next phase of this research will be to develop and test a scaled-up combustor for larger gas turbines.

Long-Term Benefits: EPAG's long-term objective of developing innovative cost-competitive, environmentally-friendly technologies for DG applications including fuel cells and hybrids. As an example of such a project, PIER has co-funded with Southern California Edison and Siemens-Westinghouse a POC demonstration of a hybrid system using an MTG and a pressurized solid oxide fuel cell (PSOFC). This 250 kW integrated hybrid system consists of a 220 kW PSOFC and a 30 kW MTG. Atmospheric emissions from fuel cells are very low because they convert fuel to electricity by an electrochemical process without combustion. MTGs typically have higher atmospheric emissions than a fuel cell. However, in the hybrid, the hot exhaust gas exiting the PSOFC is expanded through the MTG turbine, driving the compressor to pressurize the fuel cell. Remaining available energy is used to drive an

electric generator to produce additional electric power. The increased power generation occurs with no increase in either fuel consumption or atmospheric emissions.

The project risk was high because the Siemens-Westinghouse SOFC had not previously been operated in the higher efficiency pressurized mode, SOFC technologies are still in the development stage, and integration of a fuel cell with an MTG had not been attempted before. But engineering design studies predicted that mature, commercial hybrid units would be more cost competitive than stand-alone fuel cells. The result was that proof-of-concept was achieved—sustained operation with the PSOFC supplying thermal energy to drive the MTG was demonstrated. Continued development and utilization of this technology will result in air quality benefits through a reduction in NO_x and greenhouse gas emissions. The integrated PSOFC and MTG hybrid will result in an electrical generating device with at least 60 percent efficiency, equal to or greater than any other form of fossil-fuel generation.

From the beginning, the EPAG group recognized that a major barrier to marketplace acceptance of newer high-efficiency, clean MTG and fuel cell technologies was the lack of independent testing of, and recognized industrial standards for, performance characteristics of these advanced systems. Potential customers have, reluctantly, been forced to rely solely on the claims of manufacturers.

As a result of this barrier, PIER has funded a project with the University of California at Irvine (UCI) to develop standardized testing protocols and

reporting procedures for MTGs, steady state analytical tools for fuel cells, and dynamic modeling capabilities for fuel cell and fuel cell-turbine hybrid systems. The objectives of this project include: (1) providing consistent MTG performance information regardless of who performs the testing, (2) allowing a comparison between manufacturers' specifications and actual operational results, and (3) identifying critical technology barriers limiting performance of these devices and thereby identifying opportunities for future research and development efforts. The results from this project are already providing potential end-users with the confidence they need to speed the installation of these EPAG technologies into the marketplace, thus ensuring that the anticipated public benefits will be realized.

Outlook: To continue this technology development strategy, EPAG will release two targeted requests for proposals (RFPs) in 2001. The first will be for the scientific and engineering advancement of fuel cells, MTGs, and fuel cell-microturbine hybrids, and will contain specific performance targets and stretch goals. Within those performance boundaries, bidders will be able to respond with a wide variety of technical approaches. The second RFP will be for advanced reciprocating engines, focusing on specific California needs determined in collaboration with industry stakeholders. Each of these RFPs will be coordinated with the goals and funding of other RD&D organizations, such as the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), the Gas Technology Institute (GTI), and the University of California.

Fuel flexibility and fuel-to-electricity conversion efficiency will be important considerations in selecting future projects. The reasons are that (1) on-site generation with natural gas leaves the owner with vulnerability to natural gas supply and cost risks, and (2) global climate change impacts can be partially mitigated by improved efficiency, independent of the fuel.

Collaboration with successful project partners will increase. This will take two forms. First, follow-on funding will be considered. Second, greater use of EPAG-funded equipment and expertise will occur. For example, EPAG has funded a number of projects at the National Fuel Cell Research Center related to achieving better analytical understanding of fuel cells and MTG and the development of standard methods for fuel cell and MTG testing and reporting.

Energy-Related Environmental Research Successes and Outlooks

Environmental impacts occur whenever energy is extracted, collected, transported, converted, or utilized. The energy-related environmental research program area focuses its project funding on better understanding and addressing the effects of these processes. Specifically, RD&D is needed to:

- Improve air quality despite continuing urban growth
- Develop alternative water supplies to address projected regional shortages
- Reduce the adverse effects of energy systems on plant and animal species and their habitats
- Better understand and mitigate the regional effects of global climate change

Example of public benefits realized in

2000: Global climate change, which results from the release of carbon dioxide, methane, and other gases to the atmosphere, has the potential to affect all segments of society in California. PIER funds will augment an ongoing global climate change study to allow a more in-depth analysis of the potential impacts to California's ecosystems, agriculture, hydroelectric and water resources, energy consumption, and other factors affected by climate. This project is providing the following benefits:

- Provide technical information necessary to debate global climate issues and develop energy policy options
- Deliver results from analyses that can be used to develop state-level policy options for global climate change concerns
- Identify future areas of research based on their level of importance to California

Example of public benefits

anticipated in 2001: The use of dry cooling technology provides a significant reduction in a power plant's water demand. In general, a plant utilizing dry cooling requires approximately 15 percent or less water than a similar facility utilizing wet cooling technology. A significant drawback of dry cooling, however, is the inability of facilities using this technology to maintain normal electricity output during the hottest periods of the year. In California, this occurrence coincides with the greatest demand for electricity and therefore, presents both a potential concern for

system reliability and a substantial revenue loss to the plant owners.

A preferred solution is water enhancement: a small amount of water spray is introduced into the inlet air stream to the cooling tower where it evaporates and cools the air. Analysis has shown that a few degrees reduction in the inlet air temperature can restore much of the lost plant capacity during hot hours (Conradie and Kroeger 1991).

Advantages to spray enhancement are modest water use, modest initial cost, and the ability to retrofit existing units. This project will provide the following benefits:

- Use of spray enhancement at an existing 240 MW facility utilizing dry cooling may provide up to an additional 20 MW for summer 2001.
- Currently, California has up to 1,500 MW of installed capacity using air-cooled condensers and at least 500 MW of out-of-state installed capacity that could benefit immediately from spray enhancement, possibly providing up to 200 MW of peak capacity for summer 2001.
- If dry cooling is broadly adopted, thousands of acre feet of water and approximately 2,000 MW of capacity could be recovered from the 20,000 MW of planned new generation in California.

Strategic Energy Research Successes and Outlooks

The strategic program area conducts research to develop critical infrastructure technologies, including generation, transmission, distribution, end-use, control, and communications technologies all functioning in an

integrated system. The objective of this research is to effect critical infrastructure changes to allow electricity transactions to be made in the most effective, efficient, reliable, and environmentally benign means possible and provide Californians improved and customized electricity services. The strategic energy research program focuses RD&D funding on these opportunities:

- Conduct research to aid expanded use of distributed energy resources, including interconnection, dispatchability, system impacts, system integration, and transmission and distribution support
- Conduct research to develop improved communications, control, and verification technologies that improve customers' price responsiveness in a real-time market
- Conduct research to develop technologies to enhance transmission system reliability, especially in areas with increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors
- Conduct research to develop advanced energy storage technology to meet consumer needs for load leveling, power quality, ancillary services, and reliability
- Advance the scientific knowledge of seismic event impact on California's electric system and develop technologies that enhance electrical system resilience in the event of natural disasters
- Conduct research on the performance and design of electricity markets

- Conduct scoping studies to identify and support innovative, enabling and cross-cutting science and technology advancements.

Examples of public benefits realized in 2000: Consensus was forged on interconnection requirements in California (FOCUS-I).

The purpose of the FOCUS-I project was to identify the barriers to DG and make recommendations for removing those barriers, in the areas of interconnection, environmental review, and permit streamlining. This effort was critical for making DG, especially units smaller than 1 MW in size, a viable source of power for California in the future. The interconnection portion of the FOCUS-I effort achieved consensus on critical technical issues. This project has resulted in a single uniform process, which is internally consistent and predictable statewide. The California Public Utilities Commission (PUC) adopted the recommendations in 2000. Interconnection projects now use Revised Rule 21 for all DG interconnections in investor-owned utility areas in California. Simplified interconnection requirements will lower cost of new generation while maintaining appropriate safety requirements. Revised Rule 21 is estimated to have achieved approximately 50 percent efficiency in cost reduction, an average reduction in costs of approximately 37 percent for interconnection across all project sizes. The researchers have identified future R&D opportunities that could expand the applications for Rule 21. The Commission expects to continue this work in 2001.

Examples of public benefits

anticipated in 2001: Looking forward to the year 2001, highlights from the strategic program include the following.

- Real-Time Transmission Line Ratings for Path 15

This project will continue research begun under a PIER transition contract with San Diego Gas and Electric (SDG&E) Company and their subcontractor, the Valley Group. The SDG&E research demonstrated the feasibility of implementing real-time transmission line ratings for a single site in San Diego. The results showed that, at the tested location, real-time ratings indicated much higher power transfer capabilities than static ratings. The follow-on research will demonstrate the feasibility of implementing real-time transmission line ratings for Path 15, which is one of the most complex and critical gates in the California transmission system. The technical objective is to increase the power transfer capability through Path 15 by 15–20 percent on an annual basis. The economic performance objective is to decrease utility expenditures by \$1 million per month, through decreased transmission congestion on Path 15 during peak times.

This project will investigate the feasibility of providing real-time transmission line ratings by monitoring the conductor tension and environmental factors for a multiple-line transmission path and communicating the real-time data to the system operators at the California Independent System Operator (ISO) and PG&E. Monitoring of actual conductor tension provides a direct measurement of the only variable

that determines conductor sag directly. This project is unique because it provides a calculated real-time rating for the path directly to the system operators, as opposed to previous systems that store data for collection and later analysis. The demonstration phase is scheduled to be operational by June 2001 and thus be able to contribute to the summer 2001 preparedness activities by the state.

Finally, this project will also identify other possible paths in California that could benefit from real-time thermal ratings. The analysis on the applicability to other transmission paths will help California prepare for summer peak conditions beyond 2001.

- This intergovernmental agreement with the LBNL addresses the transition of California's electricity supply and delivery infrastructures from vertically integrated, regulated, and government-controlled organizations to desegregated, competitive, market-driven institutions. This project will provide integrated research and technology development that will produce quicker and more flexible options to increase the reliability of electricity services delivered to California's customers.

A new tool, the Consortium for Electric Reliability Technology Solutions – Volt Amps Reactive (CERTS VAR) Management adequacy tool, will be demonstrated this summer at the California ISO. This product provides system operators with immediate access to critical information on wide-area system voltages and, more important, to reactive reserve margins at critical

grid locations through the use of sensitivity calculations and visual geographically oriented displays. Maintaining adequate voltages and reactive reserves, which vary according to local conditions, is essential for maintaining system reliability during and immediately after a significant disturbance on the grid. Currently, system operators receive this information in the form of tabular displays or from single line-diagrams that suppress the geographic relationship among voltages at various points within the system. Tools such as these could have been instrumental in alerting operators of dangerously low reactive reserve margins at critical stations and possibly prevented widespread outages on the West Coast in 1996.

The new software allows operators to immediately grasp the information contained in vast amounts of data quickly analyze potential problems, and initiate appropriate remedial actions.

Energy Innovations Small Grant Program Successes and Outlooks

The EISG program continues to mature and flourish, exceeding initial expectations for the program. The strategy of outsourcing program administration to the San Diego State University (SDSU) Foundation through an interagency agreement with California State University has proven to be a cost-effective strategy of extending the PIER Program while minimizing the workload impact on the Commission staff.

One of the primary objectives of the program was to hold administrative costs for the EISG program to 25 percent

of the funds actually awarded in grants. As of the end of December 2000 the SDSU Foundation has exceeded that expectation by holding administrative costs to 20 percent while at the same time achieving an aggressive solicitation rate of four solicitations a year. For the year 2000, 133 proposals were received and subjected to a thorough peer review process that included 296 technical reviewers from academia, industry and the federal laboratories. The Foundation's review board recommended 39 proposals valued at \$2.9 million be funded and the Commission approved all 39 grants.

The EISG program was officially launched in September of 1998, however, the first grants were not awarded until the last quarter of 1999 and had an average term of about 16 months. As a result, the first four draft final reports were received late in 2000 and are still under review. By the end of 2001, 36 projects are projected to be completed, allowing a more comprehensive assessment of the program's successes in next year's annual report. Some of the promising technologies under investigation include:

- The gasification of municipal solid waste and sewage sludge into fuel gases that can be incorporated into modified combined cycle gas turbine power plants.
- Technologies to reduce the manufacturing costs and increase the solar conversion efficiency of PV systems.
- A variety of technologies related to fuel cells that seek to reduce system costs, increase system efficiency and increase reliability to make fuel cells a cost-effective option for distributed

power generation in residential and commercial applications.

- Technologies to reduce emissions from large gas turbines used for power generation.
- Renewable hydrogen production from microalgal photosynthesis.
- Technologies for increasing the efficiency of vertical axis and horizontal axis wind turbines.
- Solar assisted air conditioning systems to reduce electrical consumption.

C. Summary of 2000 PIER RD&D Awards

During 2000, the Commission approved public interest energy research awards totaling approximately \$16.9 million through three funding methods. These methods were competitive awards, sole-source contracts, and interagency / intergovernmental agreements.

On average, every PIER dollar is being matched by \$2.62 from PIER's research

partners. The \$16.9 million in PIER awards will be matched with approximately \$44.3 million in other cash and in-kind matching funds, thus providing approximately \$61.2 million in total funding for these public interest energy research projects.

The funding and number of projects by program area is shown in Figure 4 for 2000. Figure 5 shows the funding and number of projects by program area from the PIER Program's inception in 1998 through 2000.

PIER's 2000 awards are administered by seven program leads. There is a program lead for each of the six PIER Program areas and one for the Energy Innovations Small Grant Program. The \$16.9 million in 2000 PIER awards breaks down administratively into the following amounts:

- Fifteen awards administered by the six PIER Program Area leads total \$14.2 million

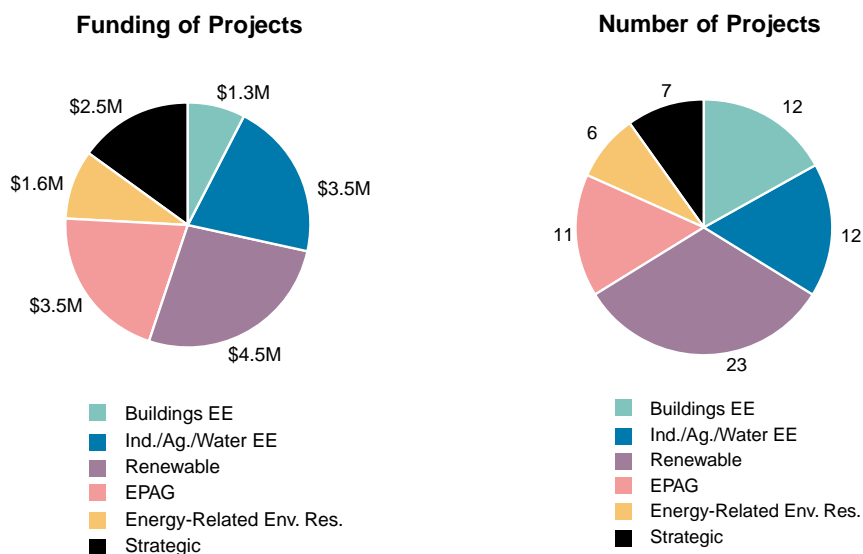


Figure 4. 2000 PIER Projects by Funding and Number of Projects

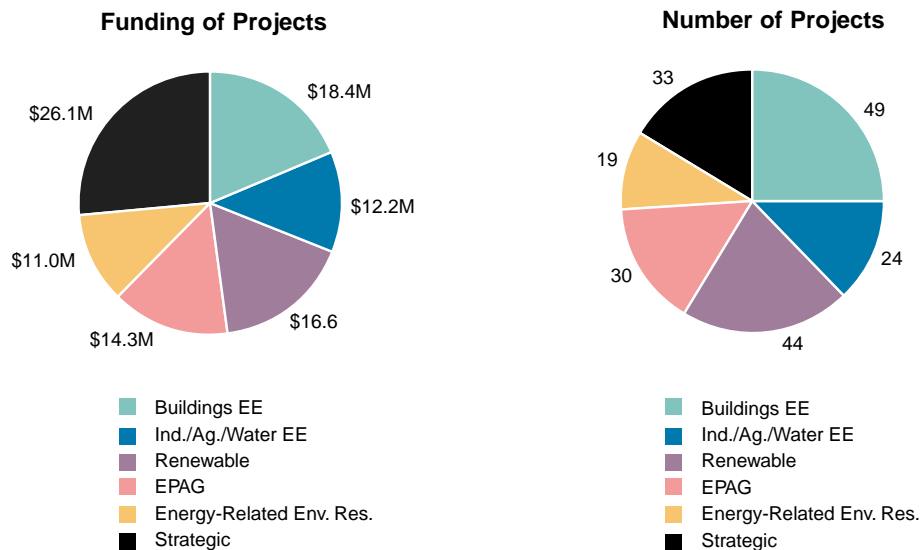


Figure 5. 1998-2000 PIER Projects by Funding and Number of Projects

- Thirty-six Energy Innovations Small Grant Program awards total \$2.7 million²

Supporting Projects Through Collaborative Research Funding

Through collaborative funding with distinguished research organizations, the Commission has leveraged its funds to meet California's energy needs at a lower cost and with greater efficiency. The Commission was able to structure collaborative projects with government and private organizations that served the interests of California residents and the constituents of the organizations. In 2000, these organizations included EPRI, GTI, US DOE and their national laboratories, and the University of California.

The partnership with EPRI enables the Commission to participate in and build on pre-existing collaborative relationships and to continue important public interest energy and environmental

research. EPRI is a public purpose, nonprofit 501(c)(3) California corporation that was established in 1973 as a center for public interest energy and environmental research.

GTI is the national RD&D consortium for the U.S. natural gas industry. It was formed last year from the merging of the Gas Research Institute (GRI) with the Institute of Gas Technology (IGT), two organizations that have delivered over 400 products, processes, and techniques to the marketplace since its inception in 1976. GTI does not perform all of the RD&D in-house, but funds the most qualified manufacturers, universities, RD&D firms, and other organizations in order to perform the research needed to bring results to the marketplace. The IGT addition to GTI allows for some in-house RD&D activities. Many California companies are included in the mix of current and past GTI contractors and partners, including the Commission.

² These 1999 grants are being funded by a \$5 million interagency agreement awarded by the Commission in 1998 to the California State University Institute.

The DOE and national laboratories have extensive programs representing national interests. Many of the interests directly affect California, and in those cases, the Commission has established collaborative projects to accomplish more with the combined funds.

Collaborative projects with the University of California allow the state to leverage funds and continue cooperation between California research organizations.

The Commission believes that collaborative research funding in the six selected program areas will improve the energy cost/value, the reliability and quality, and the public health costs/risks of California's electricity.

1. Residential and Commercial Buildings End-Use Energy Efficiency

On July 14, 2000, the residential and commercial buildings end-use energy efficiency program area released a solicitation for funding approximately three separate targeted programmatic contracts. Through this solicitation, the Commission seeks to encourage collaboration between diverse program elements where such collaboration will more effectively and efficiently address technical and market goals of the PIER Program. Three awards totaling approximately \$3 million are proposed as a result of this solicitation and contracts will be developed in 2001. These three projects were previously described in the section entitled Buildings End-Use Energy Efficiency Issues, Successes and Outlooks.

During the second quarter of 2000, the Commission approved a \$50,000 contract with the Lighting Research

Center (LRC), based in Troy, New York. This center was formed in 1988 with the goal of changing architecture through lighting that is energy efficient and responsive to human needs. Since then, the LRC has grown into the world's largest university-based center for lighting research and education.

This contract will enable the Commission to learn first hand from the lighting industry the status of current lighting research, and to better identify areas of needed future research. In addition, it will enable the Commission to gain knowledge from the LRC's R&D efforts, and to participate with lighting industry professionals in steering the direction of the LRC's lighting research agenda.

During the fourth quarter of 2000, the Commission approved a \$300,000 contract with the Air Conditioning and Refrigeration Technology Institute (ARTI). Membership with the ARTI will enable the Commission to leverage research expenditures by collaborating with other members in supporting needed research related to HVAC. Through an intensive effort that included widespread industry participation, ARTI has identified specific pre-competitive research needs and is currently supporting research identified through this industry process. Areas of specific interest to the Commission and which align well with the PIER Program's goals include proposed research in equipment energy efficiency, system integration, and indoor environmental quality. This contract will enable the Commission to steer the specific direction of the research and participate with industry members and technical experts in reviewing early research results. In addition, it will provide the Commission

with a direct link to industry needs in the HVAC arena.

2. Industrial/Agricultural/Water End-Use Energy Efficiency

The program funded two major projects.

- The program awarded a \$2 million sole-source contract to the Metropolitan Water District (MWD) and a consortium of utilities in Southern California for research and development of energy-efficient water treatment processes and technologies. The goals of the project are to develop and demonstrate advanced desalination and water disinfecting technologies that are energy efficient and can treat a large volume of potable and non-potable water. Besides energy savings in water treatment, the removal of dissolved solids from Southern California's water supply results in avoidance of economic damages to private and public sectors. MWD estimates a savings of \$95 million per year by avoiding damages to the public and private sectors for every 100mg/liter of total dissolved solids over the designated level of 500mg/liter.
- The program entered into a \$352,000 contract with the LBNL for research and development of design tools and a guidebook for energy-efficient clean rooms for high-tech industries and laboratories. In addition the contract will support field demonstrations and tests of the low-flow fume hood. In 1997 energy intensive buildings housing laboratories and clean rooms for high-tech manufacturing consumed 9.4 billion kilowatt-hours of electricity in California. The number

of these buildings, and their energy intensity continues to grow.

3. Renewable Energy Technologies

Awards made in the PIER Renewable Energy Technologies area during calendar year 2000 focused on three major themes: 1) obtaining a better understanding of what changes or advancements in renewables are required to help meet needs of California's electricity customers; 2) improving the ability of California's existing renewable energy facilities to assist the state's electricity system; and 3) further developing renewable energy distributed generation technologies. Five awards were made totaling over \$2.7 million.

The Commission provided EPRI \$340,352 to conduct a market assessment and benefits analysis related to renewable energy development in California. Under the study, EPRI will determine how renewable energy technology developers and manufacturers are positioning themselves to remain competitive in California's new electricity markets, and the types of advances and improvements the industry believes are needed to help achieve this competitiveness. In addition, EPRI will identify and estimate the types and magnitudes of public benefits that will accrue to California if such advancements occur. A draft version of the final report has been completed and is under review by the Commission.

The Commission also provided EPRI \$330,000 for membership in Target 66 (Renewable Energy Technology Options). Under this target, EPRI will provide the Commission information

on collaborative efforts in the areas of biomass cofiring with natural gas, advanced wind energy developments, and photovoltaic interconnection issues. In addition, EPRI will provide the Commission with an updated technology assessment guide specific to renewable energy technologies (TAG-RE). The TAG-RE provides information on the current status of renewable energy technologies, and a quantitative assessment of the technical, environmental and economic issues confronting further development of the technologies. A final version of the TAG-RE was delivered to the Commission in March 2001.

A third award was made to EPRI for \$444,324 for development of a California Wind Energy Forecasting System. Wind energy systems account for approximately 1600 MW of the state's generating capacity, and provide nearly three billion kilowatt-hours per year of electricity. However, because of the intermittent nature of the wind, it is difficult to know in advance how much of the electricity from wind energy systems will be available to help meet peak electricity needs. For large wind parks, wind flows are critical in determining when to schedule outages, in assessing if the costs of bringing older, less efficient turbines is sound, and in identifying high wind conditions that may require locking out turbines. Consequently, advance information on wind speed and direction could help optimize wind park operations and ensure improved generation of wind energy systems. The goal of the California Wind Energy Forecasting System is to provide forecasts that provide wind information on an hourly basis for up to 48 hours in advance of the forecast for wind sites in California.

Currently, three preliminary wind forecasting systems are under evaluation.

Two awards were made to help further development of renewable distributed generation systems powered by biomass. An award of \$645,827 was made to Community Power Corporation (CPC) for development of a 12.5 kW biopower generation system. Designed to be operated either remotely or grid-connected, the biomass powered system can provide dispatchable electricity in areas lacking natural gas, but which have available biomass resources. In addition, the CPC system offers a possible avenue for removing forest overgrowth from areas facing high risk of wildfires, but that cannot environmentally sustain a large biomass power plant. Under the contract, CPC will develop and demonstrate the system at the Tsemata Forest Regeneration Complex owned and operated by the Hoopa Valley Tribe in Northern California. Forest thinnings collected from the complex will fuel the system, which in turn will supply electricity and heat currently purchased by the tribe for use in the complex.

An award of \$983,653 was made to FlexEnergy for the development and demonstration of an innovative microturbine system that can operate on a variety of different biomass fuels. The goal of the project is to develop a highly responsive and cost competitive distributed generation system that can be powered by biomass resources that currently pose significant environmental issues in California. In particular, the system will be tested on biogas generated from anaerobic digestion of livestock manure, producer gas generated from thermal gasification of

orchard and forest residues, and biogas collected from a landfill gas recovery system.

Both the CPC and FlexEnergy projects were awarded under an innovative new solicitation that allowed the Commission and applicants to negotiate the work to be conducted in the proposed projects. Typically, state contracting procedures have limited the Commission to either accepting a proposal as written, rejecting the proposal, or placing special conditions on the proposal. The first two options leave little advantage for the state if the proposal is generally in line with the needs of the solicitation, but far enough away to be acceptable as written. In the event the Commission attempts to resolve the problem by placing special conditions on the award, the applicant and Commission must still reach agreement about the contract conditions even if the proposed award is approved at a Commission Business Meeting. As a result, contract conditions may not be set for an extended time and critical progress lost in the project. Under the Competitive Negotiation Solicitation (CNS), the ability to negotiate over the work and budget resolves the differences. As a result, the award proposed at the Business Meeting becomes the contract, resulting in a considerable saving of time. In the specific case of the Small Modular Biomass CNS, the Energy Commission estimates it saved nearly two-thirds of the typical "solicitation-to-final-contract" time.

4. Environmentally Preferred Advanced Generation

EPAG evaluated a proposal from the University of California, Irvine, National Fuel Cell Research Center, for

four related but different projects with a total funding request of \$2,259,851. The Commission issued a contract for three of these projects for \$1,409,177 on July 12, 2000. The three projects are:

- The Steady State Analysis Tools project—a continuation of work funded under a previous PIER award,
- The Fuel Cell Hybrid Dynamic Modeling project—a new project but is related to the Steady State modeling effort, and
- The Microturbine Generator Testing Protocol Development project—a new area of research.

The three projects are consistent with the EPAG goals in that they provide a higher level of understanding of the potential and actual performance of fuel cells, MTGs, and fuel cell/MTG hybrids. Higher temperature fuel cells that are the subject of two of the projects have higher fuel-to-electricity conversion efficiencies than the commercially-available but lower temperature phosphoric acid fuel cell. MTGs are now being offered by some manufacturers as commercial units, while other manufacturers are providing units for pre-commercial field testing. The three projects provide benefits to manufacturers and users of the systems by developing products for their use. The system models or simulations will facilitate both the design and the performance characterization of new generating systems and cycles and will identify fruitful areas for further research and development. The Steady State Analysis Tools and the MTG Protocols project will provide uniform industry standards and procedures for the

testing of fuel cells and MTGs and for the reporting of results on a consistent and unbiased basis. This will give prospective purchasers greater confidence in system performance, durability, and suitability.

Another new EPAG contract for follow-on funding of \$1,311,768 was also provided to Alzeta Corporation to test the low NO_x combustor previously developed for a microturbine and to develop prototype combustors for larger industrial-scale turbines. Low NO_x combustors are required if small and MTGs are to operate in non-attainment areas and under increasingly stringent air quality rules. Post-combustion cleanup is not cost effective at smaller engine sizes and has undesirable features such as the need to use ammonia. Successful application of the Alzeta technology would make new classes of gas turbines available for distributed generation in California.

5. Energy-Related Environmental Research

The mandate of the PIER Environmental Area (PIEREA) is to address the environmental impacts of electricity generation, transmission, distribution and use. In 1999, the Commission agreed to engage in a two-year membership with the EPRI. In 2000, the PIEREA entered into collaborative agreements with EPRI to address environmental issues on: Hydropower Operations; Fish Protection; Water Management; Multimedia Toxics Characterization; and Water Quality Criteria. The decision to fund these targets took into consideration the anticipated public benefit, value of the target relative to its cost, and quality of existing deliverables. The following is a description of these projects:

- Hydropower-related R&D is examining cost-effective solutions to address critical relicensing, environmental, and public issues related to the hydro industry. This project is investigating best practices for relicensing; flows and cost-effective designs to improve fish passage and reduce mortality, and; information and issues of concern regarding decommissioning (dam removal and ecosystem restoration) and sediment disposal.
- The protection of single fish species and aquatic communities is a primary focus of water permitting for power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This project supports research into cost-effective fish protection technologies and facility operational decision-making. The type of information developed through this target is critical to an understanding of biological impacts and therefore to regulatory decision-making.
- Facilities Water Management proposes specific actions to help understand how to reduce the consumption of water for power plant cooling needs and to reduce the impact on the environment from the discharge of power plant cooling wastes. A major focus of this project is the development of non-oxidizing biocides for bio-fouling control in cooling towers.
- R&D to support the use of a multimedia approach as a design tool for minimizing the environmental effects of new power plants was funded in

2000. This research funded development of a multimedia model known as PISCES. The project was suspended because the collaborative membership elected to focus initially on developing the model on an application for coal-fired power plants—a fuel rarely used in California.

- PIEREA supported R&D related to the development of water quality criteria and assessment of the impacts of release of toxic chemicals in aquatic ecosystems. This project is developing data and models to assess the metals toxicity, bio-accumulation of metals, and assessment of contaminated sediments. This research is focusing on the metals arsenic, mercury, and selenium.
- PIEREA also funded an Emissions Testing and Certification Guidelines for Distributed Energy Resources tailored collaborative project. This project was designed to reduce the cost and time for permitting distributed electricity generation technologies through the development of emission testing protocols and a fleet certification program.

6. Strategic Energy Research

Work began in 2000 on the \$7.2 million contract awarded to the LBNL and the Consortium for Electric Reliability Technology Solutions (CERTS) in 1999. The project will provide integrated research and technology development that will produce quicker and more flexible options for meeting the reliability, stability, and ancillary service needs of California's electricity consumers.

In March, the Commission allocated \$80,000 to EPRI to participate in a collaborative on linked infrastructure security. The purpose is to investigate security activities across linked infrastructures such as the phone system, Internet, and electricity system. As gateways to the electricity system, these infrastructures demand increased sharing of information. Security issues will be identified and protective measures will be analyzed. Products will include a Security Primer and Guidebook and a scoping study of the nature of security risks and mitigation approaches.

In June, the Commission allocated \$32,000 to EPRI to undertake a study on using dynamic simulation to understand power plant construction cycles. The objective is to evaluate the economics and dynamics governing construction cycles in the building of electric generating capacity. Deregulation has changed the procedures and considerations through which capacity is added. Simulation tools will be developed that aid the understanding of the interplay between market structure and investment behavior.

The Commission awarded a \$74,999 contract augmentation to ONSITE SYCOM Energy Corporation in July 2000. The augmentation added tasks to complete the contractor's development of consensus standards for DG interconnection and permit streamlining. The initial work was deemed highly credible by the commission, as well as the utilities and manufactures, but the process was more intense and complicated than initially anticipated. The augmentation allowed the project

to continue and resulted in collaborative, adopted interconnection standards, removing a significant barrier and allowing DG to enter the market at a lower cost.

In November, the Commission awarded a \$1,100,479 contract to W. Brandt Goldsworthy & Associates, Inc. to develop a composite reinforced aluminum conductor (CRAC) for transmission lines. This will continue research begun under PIER contract number 500-98-035 with the same contractor. Under the first PIER contract, the contractor successfully completed a \$75,000 research effort to determine the feasibility of using a CRAC TelePower in applications dominated by the standard aluminum conductor, steel reinforced (ACSR), known in the industry as a DRAKE conductor. The follow-on research will develop prototype-manufacturing technology for CRAC and demonstrate the conductor's performance on a 2,000-foot (nominal) 3-phase span using Southern California Edison's facilities. The new conductor has advantages of higher amp loading for the same cost as DRAKE, and the potential for carrying digital and analog signals for communications and conductor diagnostic purposes. This project will improve the reliability and capability of California's transmission and distribution system by developing a stronger and lighter conductor to replace aging and overloaded power lines.

In December, the Commission awarded a \$2,050,000 grant to the University of California Energy Institute to fund a center to conduct academic research into the performance and design of electricity markets. Work will begin in the spring of 2001.

Funding Projects through the Energy Innovations Small Grant Program

The EISG Program was created to meet three needs for the Commission's overall PIER effort:

- Provide research support for innovative ideas not necessarily covered in the targeted PIER Program area research plans.
- Provide a user-friendly application process to groups that are adversely affected by the high transaction costs associated with the Commission's standard competitive bid processes. These groups are small businesses, individuals, academics, and non-profits.
- Provide a PIER funding mechanism for early concept feasibility research and development. The mainstream PIER research efforts require that feasibility has already been established.

In addition, the Commission wanted to design a program with minimal demand on scarce staff resources. To accomplish this, the Commission approved a two-year, \$5 million interagency agreement in September 1998 with the California State University Regents to administer the EISG program. The Regents contracted with the SDSU Foundation to perform the day-to-day administration functions. The Foundation, in coordination with the Commission, developed a simplified funding application process to identify and recommend worthy POC projects to the Commission. The Commission, in turn, participates in the project review process and maintains final authority to approve any projects that are

recommended by the administrator. The Commission extended the interagency agreement with the California State University Regents for another two years in September 2000.

In 2000, the Commission conducted four solicitations for the EISG Program and approved 39 grants valued at \$2.9 million. Twenty-nine grant award contracts valued at \$2.2 million were executed in the year 2000. A total of eight solicitations have been conducted since the program started in 1998, resulting in 54 grant award contracts valued at \$4.03 million.

Figures 6 and 7 show how EISG Program awards are distributed among the six PIER program areas and by applicant type.

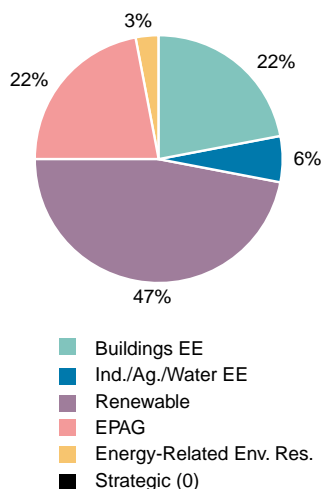


Figure 6. Energy Innovations Small Grant Program Awards Analyzed by Program Area

D. PIER Program Administration

1. Improving the PIER Program

Another important objective of the Commission's RD&D strategic plan is to ensure that the PIER Program is administered in an efficient and effective manner. Given that the PIER

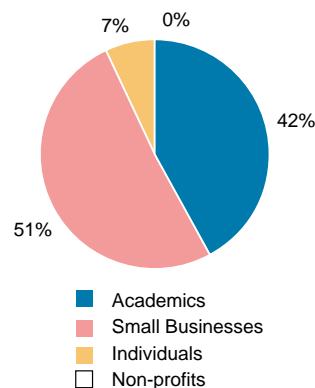


Figure 7. Energy Innovations Small Grant Program Awards Analyzed by Applicant Type

Program areas discussed above cut across all divisions of the Commission, a new organization and reporting structure was developed to address these needs during the PIER transitional period. In 1998, interdivisional teams were created to address issues and responsibilities in each of the six PIER Program planning areas. This solved communication issues but created a complex reporting process that inhibited the development of the PIER Program. In 2000, a new organizational structure was created to ensure that the PIER Program is not hampered by crossing interdivisional lines. Under this new structure, the PIER Program is housed within the Technology Systems Division and all Team Leads reside in this division. The Technology Systems Division Director is also the PIER Program Manager.

The PIER Program Manager was identified and the Program Manager and Team Leads for all subject areas are now in place. Their roles and responsibilities, while still being fine-tuned, are reasonably well defined. The Program Manager has clear authority to make decisions. Team Leads are responsible for solicitations and awards,

contract management, project integration, subject area planning, and budget development. The Program Manager relies upon the Team Leads to assist in long-term strategic planning. Program support staff are responsible for contract streamlining, technology transfer, information management, budget development, and program evaluation and integration.

To further improve PIER's operating efficiency, the Commission revised its contracting procedures to streamline a formerly cumbersome process. The Commission now uses customized contract terms and conditions that have dramatically reduced the time and effort required for executing contracts. Competitive negotiation regulations were adopted to allow the Commission to negotiate the details of competing proposals, thus improving the quality of the proposals. In addition, contracts can now be awarded to PIER projects on a sole or single-source basis.

2. Independent Review Panel (and the Commission response to March 2000 IRP Report)

In March 2000, the PIER Independent Review Panel (IRP)—comprised of energy research and policy experts—filed the first of two reports to the Legislature on the evolution and status of the PIER Program. The IRP found many valuable reasons to continue the program, but also made recommendations on how the program could be improved. The findings include the following:

- Energy-related issues are important enough in California to warrant a targeted, effective energy RD&D program.

- The state has the intellectual resources and economic infrastructure to address those challenges through a well-managed, high-quality RD&D program.
- The importance of energy RD&D to California's continued economic growth, environmental performance, and science and technology leadership demands that the PIER Program be implemented effectively.

Despite myriad successes, the IRP found that PIER has suffered from a variety of problems—many administrative—that hamper its effective execution. These included:

- The lack of a program director responsible for program planning and execution for 20 of the 24 months (as of March 2000) since the program's inception
- A mismatch and lack of clarity between responsibilities, authority, and assets for managers
- Limited coordination among the Commission elements supporting the program
- An overly complex and time-consuming contracting process for PIER projects
- Unclear connections among other federal and private-sector energy RD&D activities, California's future energy-related needs, program goals, and public interest criteria

The IRP also felt it was important to increase the autonomy and flexibility of PIER within the Commission by raising the stature of PIER, clearly defining the roles of the Commissioners and vesting greater responsibility with the PIER Program.

Many of the leadership and management issues raised in March 2000 by the IRP have been resolved and their recommendations put into effect as discussed in the previous section. The record is also good for the IRP's second area of concern, policy and planning. The development of the PIER Five-Year Investment Plan focused on this effort. A vision has been developed, consistent with the PIER Program's mission and California's needs. The operational definition of public interest criteria has been clarified. The Commission's work has better defined program context in terms of state problems and current state, federal, and private activities. Problem areas have been identified and a set of focused strategies have been developed to address them. While implementation remains a work-in-progress, PIER already funds programs consistent with our strategies. These will be further refined by developing road maps, which can be used for measuring success with predefined metrics.

The Commission's record is more mixed in the third area of the IRP's recommendations, that of administrative issues. While some progress in contract reform has occurred, problems within the Commission remain. A more streamlined approach to contracting and Request for Proposal development is underway. The Commission is looking for ways to expedite the creation of agreements, including making greater use of grants and purchase orders, and other available funding mechanisms as appropriate. Also, state-mandated limitations on the Commission's procedures may necessitate external changes.

Staffing remains a major internal problem. The lack of staff has caused the PIER Program to fall behind schedule in project funding. The inability to create new positions and the lack of opportunities for existing staff decrease the Commission's capacity to attract and retain high-caliber staff. PIER will consolidate its operations within an independent division led by the Program Manager to allow better operational control with less reliance on matrixed staff as discussed in the previous section. Some legislative relief may be necessary in both the administrative and staffing areas.

PIER is using innovative approaches to solving staff issues. The Commission made use of the Interagency Jurisdictional Exchange mechanism to bring in the Program Manager, and is exploring using this mechanism to acquire new staff from the University of California. The Commission intends to make greater use of technical support contractors, as well as obtain broader support from key research and development contractors. The use of technical advisory panels will be expanded in all subject areas. The goal is to reach an intellectual and operational critical mass for the PIER Program, which it is currently lacking.

3. Technology Transfer

The value of energy RD&D is lost if the results are not made available to potential users, investors, or marketers. Concurrently, many smaller businesses don't have the resources or expertise to launch their clean energy technology or products. The PIER Program is addressing these technology transfer

issues by continuing to publish final reports on PIER projects, launching its new website, and participating in an innovative energy business incubator project which will assist PIER-funded enterprises in the transition from a technology-focused start-up company to a successful market-based business.

In addition, the Commission cosponsors technical conferences with other distinguished organizations to leverage PIER funds to more efficiently transfer information and technical knowledge. In November 2000, the Commission cosponsored the Distributed Power Coalition of America (DPCA)/California Alliance for Distributed Resources (CADR) 2nd Annual International Symposium on Distributed Energy Resources in San Diego, California.

4. PIER Program Reporting to the Legislature

Until January 1, 2001, Public Resources Code Section 25620.5(h) required the Commission to provide to the Legislature, on a quarterly basis, an "evaluation of the progress and a status of the [PIER Program's] implementation to date."³ In 2000, the Commission completed and filed each of these Quarterly Reports with the Legislature in a timely manner. Public Resources Code Section 25620.8 also requires the Commission to report annually to the

Legislature on the status of the PIER Program. This 2000 PIER Annual Report is being provided in a complete and timely manner.

5. 2000 Financial Statement (January through December 2000)

The financial statement for the PIER Program in 2000 is shown in Table 1.

Table 1. 2000 Financial Statement

2000 Income	
Payments from Utilities:	\$61,800,000.00
Interest Earnings:	\$5,332,864.51
TOTAL Income:	\$67,132,864.51
2000 Expenditures	
Program Funding:	\$30,266,315.00
Program Administration:	\$4,945,621.12
(Personal Services \$1,311,826.12; Prorata \$736,658.50; Technical Support Contracts \$2,866,545.42; and OE&E \$30,591.08)	
TOTAL Expenditures:	\$35,211,956.12
2000 Reserves	
Available for Future Allocations:	\$31,920,928.39

³ Senate Bill 1299 (Chapter 536, Statutes of 2000) modified PRC Section 25260.5 (h). Effective January 1, 2001, the Commission is required to provide *semi-annual* (rather than *quarterly*) updates for the PIER Program. In accordance with this legislation, the Commission began its transition to a *semi-annual reporting cycle* during the last quarter of 2000. The Legislative Analyst has requested that future *semi-annual* PIER Program updates be submitted on or before June 1 and December 1 of each year. However, the Commission's *annual* PIER Report requirement was not changed by this legislation and the annual report will continue to be filed with the Legislature on or before March 31 of the year following the reporting cycle in question.



P I E R

Public Interest Energy Research

CALIFORNIA ENERGY COMMISSION

III. Future Program Directions

A. Future Funding Efforts

The four primary problems identified in the California Energy Context have been further refined into a series of goals and related categories of planned PIER RD&D activities.

Electricity demand has been increasing faster than supply. The PIER Program will address this problem by funding RD&D aimed at the following:

- Increasing supply – PIER will fund the development and implementation of renewable and small-scale fossil fuel generation facilities that have the potential to substantially add to California's electricity supply. These small-scale facilities can be sited near customer load centers. This effort will include environmental research and assessment programs to ensure that adverse impacts are not overlooked.
- Reducing demand – PIER will support the development of technologies and systems to improve the efficiency of operations, such as

cooling and lighting in existing buildings, and the development of technologies and strategies to improve the energy-efficient design, construction, and operation of new buildings. PIER will also support the development of more efficient processes and technologies for industry, agriculture, water pumping, and water and waste treatment. These and other PIER efforts will be enhanced by efforts such as technology incubators to improve the market use of PIER advanced systems.

- Developing better information and decision-making tools – PIER will fund the development of advanced sensors, models, and systems for real-time feedback and control of electricity usage. These systems will couple information on use, performance, and pricing to minimize cost while optimizing energy use.

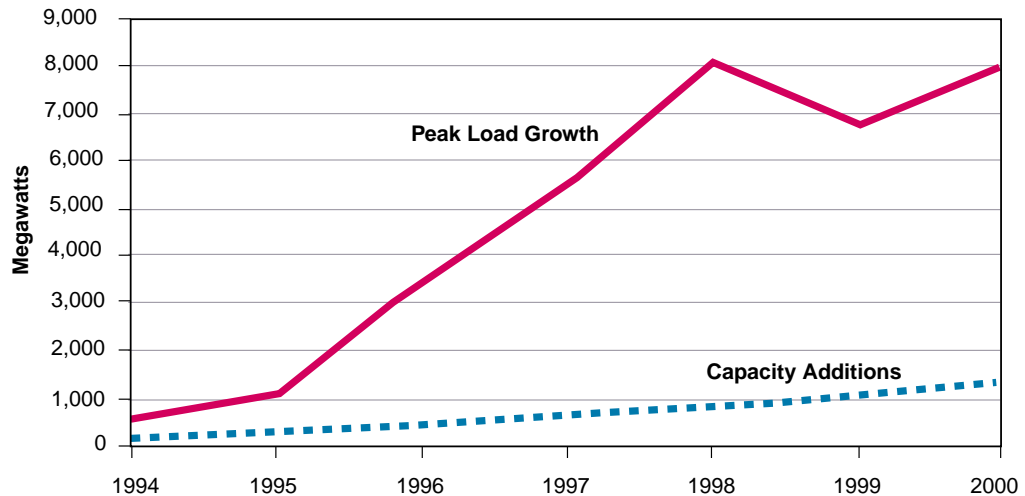


Figure 8. Peak Demand is Increasing Faster than Newly Installed Capacity

Rising peak demand threatens reliability and power quality. The PIER Program will address the problem of rising peak demand (as shown in Figure 8 above) by funding RD&D aimed at the following:

- Increasing local generation technology options – PIER will fund technologies that will provide improved operational characteristics for renewable and advanced gas-fired generation in on-site and distributed generation applications. These activities will focus on technological advances that will decrease capital and operational costs, increase efficiency, reduce emissions to the environment, and support integration of distributed generation within the power grid.
- Reducing and shifting peak demand to off-peak periods – PIER will fund the development of storage and conversion technologies to use off-peak generating capacity to meet demands at peak periods, as well as the development of more efficient

end-use technologies for areas of demand that are major contributors to peak loading, such as residential and commercial air conditioning and lighting. In addition, PIER will support the development of power conditioning technologies that allow the maintenance of power quality in critical industries. PIER will develop load management systems and technologies for real-time metering and pricing to inform and motivate consumers to shift demand to off-peak periods.

- Enhancing the performance of transmission and distribution systems – PIER will fund programs that lead to enhanced power grid performance by reducing congestion and increasing reliability. These will include new numerical models, information systems, sensors, and software to bolster system operation and allow the integration of distributed generation systems.

Balance is needed between energy needs and environmental protection. The PIER Program will address the problem of balance between energy and the environment by funding RD&D aimed at the following:

- Improving the prediction, measurement, and mitigation strategies of environmental impacts from electricity systems – PIER will accomplish this by developing a science base to evaluate potential environmental impacts and offer solutions to ameliorate those impacts. PIER will address the full range of impacts from all electricity-related activities, from generation to transmission, distribution, and end-use.
- Developing electrical technologies that benefit the environment – PIER will develop technologies that solve costly environmental problems while producing electricity in the process, such as biomass reactors for the processing of agricultural, dairy, and forest waste. In addition, PIER will fund the development of new electricity end-use technologies and new control technologies that are substantially cleaner and more efficient than those replaced.

Market uncertainty and price volatility are impacting energy delivery and use.

The PIER Program will address this problem by funding RD&D aimed at the following:

- Improving the understanding of California's energy market structure and rules – PIER will support the development of advanced knowledge of how energy markets work, identifying opportunities to improve operation of markets in California.

This better understanding of market dynamics will provide valuable insight and advice about possible changes to rules and regulations to make the system more efficient, reduce risk, and allow more flexible, multidisciplinary approaches in the system operation.

B. Strategies of the PIER Five-Year Investment Plan

The PIER Program has adopted a portfolio and budgeting approach to effectively balance the risks, benefits to ratepayers, and time horizons for various PIER activities and investments. In addition, the program will continue to establish various linkages with other energy RD&D institutions with whose collaboration the Program will be able to multiply its own effectiveness.

Design of the PIER Portfolio

The RD&D portfolio will meet the following criteria:

- *Apply an integrated set of technology RD&D strategies to California's energy problems* – There is no one technology solution to California's four primary energy problems, nor will the RD&D activities of any one PIER subject area suffice to address any one of these energy problems. The program planning strategy must, therefore, be built on a selection of the more promising science and technology RD&D opportunities from across the subject areas, which can be combined to become joint solutions to the set of energy problems. This is the vision of a portfolio of integrated RD&D strategies and solutions.
- *Address different time frames for impact on the market and different challenges along the RD&D spectrum* –

Maintaining and enhancing a balanced portfolio of technologies in various stages of development is critical because of the complexity of the problems facing California. RD&D activities will range from feasibility studies on new, longer-term energy concepts to applied research, technology development, and demonstrations. Some of the PIER Program's near-term projects could be commercialized and provide benefits by 2002 while many other successful projects will provide benefits over the course of the next decade. The program will also fund some higher-risk research that has the potential for significant breakthroughs in the long term.

- *Fund integrated solutions for major energy problems* – Integrated RD&D activities will have the potential to produce enhanced benefits through their synergies and coordination within the PIER Program and with other RD&D programs. The PIER Program will seek to leverage its funds with co-funding or in-kind contributions from other private, regulated, or public sector participants. These efforts will be coordinated with market participants and other public goods programs to ensure that the results reach the market as quickly and efficiently as possible.
- *Provide for market connectedness* – To reduce the risk that RD&D results will not reach the market and produce benefits, some PIER solicitations require a programmatic approach to solving problems. This means that bidders must propose a linked set of RD&D projects employing a mix of technologies that address a common

barrier or seek a common goal. To accomplish this, bidders must use a team of expert participants who will work across organizational and institutional boundaries to implement complete solutions, including market entry.

Budgeting for Program Effectiveness

The five-year investment budget for the PIER Program must balance the competing objectives of addressing the four major energy problems facing California, maintaining flexibility to respond to the unpredictable changes that are likely to occur, and adhering to the criteria described above. This will be done by (1) dedicating a minimum of \$165 million (approximately one-half of the funds available over the five years) to implementing the various strategies designed to address the four problems shown in Table 2; and (2) reserving the remaining available funds (approximately \$147.5 million over five years) to be competitively allocated to specific activities and strategies based on their expected public interest benefits.

Funds will be allocated based on the road maps to be developed for each subject area and on overall program goals. These road maps will contain criteria for project selection and a set of metrics to gauge project and program impacts. The Program Manager will retain funds that will be allocated to subject areas as new opportunities are identified. This approach provides an appropriate mix of focus and flexibility for meeting program goals. The funding process must remain flexible as the relative importance of issues change.

Table 2. PIER Program Budget for 2002 through 2006

Electricity Problems of Highest Concern in California	Five-Year Budget (\$ million)
1. Electric demand is increasing faster than supply.	\$50.0
2. Rising peak demand threatens reliability and power quality.	\$50.0
3. Balance is needed between energy needs and environmental protection.	\$50.0
4. The market protection uncertainty and price volatility are impacting energy delivery and use.	\$15.0
Dedicated five-year competitive budget	\$165.0
Reserved five-year competitive budget	\$147.6
Total five-year budget at \$62.5 million per year	\$312.5

Notes:

- 1) For the remainder of 2001, the PIER Program will continue to follow the existing PIER Strategic Plan with actual RD&D activities that are consistent with the comments received from both the Policy Advisory Council and the Independent Review Panel.
- 2) Initially, Problem #4 will be funded at a lower level than the other three problems because its strategies overlap those for Problems #1 and #2, and other strategies and activities to address this problem may be less amenable to RD&D solutions.

C. Coordinated Funding Efforts

In 2001, the Commission plans to continue collaborative research projects with the US Department of Energy (DOE), University of California (UC), Electric Power Research Institute (EPRI), the Gas Technology Institute (GTI), and Air Conditioning and Refrigeration Technology Institute (ARTI).

To better coordinate the efforts of the PIER Program with the energy-related RD&D accomplished in other states, the Commission will continue its involvement with the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).

Acknowledgments

The California Energy Commission wishes to acknowledge the invaluable contributions made to the PIER Program by the Commission's staff, the members of the PIER Policy Advisory Council, and the many concerned citizens who have actively participated in PIER-related advisory groups, planning focus groups, and other program forums to date. This participation has provided essential input throughout the program's development, and the Commission will continue to seek such input and assistance in the future as we strive to further develop and improve the PIER Program. The Commission also wishes to acknowledge the individuals who have agreed to serve on the Independent PIER Evaluation Panel authorized by the Legislature. Finally, the Commission wishes to acknowledge the many highly talented and creative researchers and research organizations that are participating in the PIER Program. Without the team effort of these various dedicated participants, the important public benefits of the PIER Program could not be achieved.

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Dr. Esteban Soriano

established his own market research and program assessment company (The Resource Group), specializing in educational and economic assessments. He currently serves as Vice President for University Advancement at California State Polytechnic University, Pomona. He is an expert in communication strategies, economic impact studies and assessments, methodology and research design, and has extensive experience relating to electric and water utilities.

Dr. James L. Sweeney

is Professor of Management Science and Engineering, Stanford University. Dr. Sweeney has 25 plus years of experience working in energy and environmental economic issues, having worked at the federal level in the Federal Energy Administration in the 1970's. Dr. Sweeney has a long history of research and analysis in energy economics and technology issues. He has also contributed to a number of National Energy Plans, has been a member of numerous National Research Council committees and was one of the founding members of the International Association for Energy Economics.

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is Associate Vice Chancellor - Extended Studies and Public Programs and Adjunct Professor in the Department of Sociology at the University of California, San Diego. She is the recipient of many awards and honors, among them a Kellogg Foundation national fellowship. Dr. Walshok serves on the board of the California Council for the Humanities and is a member of numerous community boards and professional associations including the San Diego Community Foundation, Girard Foundation, Eureka Communities, Foundation for Enterprise Development and ACCION.

Carl J. Weinberg

is currently a private consultant after retiring from Pacific Gas and Electric Company, where he worked for almost 20 years including eight years as Manager of Research and Development. Mr. Weinberg has been a contributor to the development and implementation of corporate, industry and national energy policies and strategies through research program management. He has extensive understanding of energy technologies, including commercial and potential renewable and conservation technologies, and has demonstrated effectiveness at accelerating technology readiness and proving technology benefits.

APPENDIX A

- **Projects funded in 2000 through the PIER Program Areas**
- **Projects funded in 2000 through the Energy Innovations Small Grant Program**
- **Projects In-Progress**
- **Projects Completed**

Appendix A Contents

Projects Funded in 2000 through the PIER Program Areas

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

- A1 Cofund 50, Developing an RD&D Plan for the PIER Buildings Team to Address Indoor Air Quality in California Buildings
- A1 High Performance Commercial Building Systems Program
- A2 Air Conditioning and Refrigeration Technology Institute (ARTI) Membership
- A2 Characterization of Framing Factors for New Low-rise Residential Building Envelope

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

- A3 Agriculture Energy End-Use Efficiency
- A3 Metropolitan Water District of Southern California (MWD)
- A4 Energy-Efficient Laboratories and Cleanrooms for High-Tech Industries

RENEWABLE ENERGY TECHNOLOGIES

- A5 Cofund 58, California Renewable Energy Technology Market and Benefit Assessment
- A5 Accelerated Lignin Tests for Biomass Power Plants
- A6 Research, Develop and Demonstrate 12 kW Small Modular Biopower System

ENVIRONMENTALLY PREFERRED ADVANCED GENERATION

- A8 Microturbine Generators, Fuel Cells and Hybrid Systems Development
- A8 Design, Develop and Demonstrate Small modular Flex-Microturbine That Will Run on Low-Energy and Low-Pressure Biomass Gases
- A10 Low NO_x Gas Turbine Combustors for Distributed Power Generation

ENERGY-RELATED ENVIRONMENTAL RESEARCH

- A11 PIER Environmental Energy Research Program Technical Assistance

STRATEGIC ENERGY RESEARCH

- A12 Electric System Reliability Enhancements
- A12 Development of a Composite Reinforced Aluminum Conductor

Projects Funded in 2000 through the Energy Innovations Small Grant Program

SOLICITATION 99-03 AWARDS

- A14 Novel Composite Membranes for Fuel Cells
- A14 Development of a Unique Gas Generator for a Non-Polluting Power Plant
- A15 Integral Catalytic Combustion/Fuel Reforming for Gas Turbine Cycles
- A16 Plug-In Photovoltaic Receiver for Concentrator Applications
- A17 Reduced Cost Power Electronic Converter for Generator Applications
- A17 Attic and Crawl Space Ventilation Air Heat Exchanger
- A18 Reducing Cost and Environmental Impact of Geothermal Power Through Modeling of Chemical Processes in the Reservoir
- A19 Catalytic Stabilizer for Industrial Gas Turbines
- A19 Ventilation Cooling Controller Strategies

SOLICITATION 99-04 AWARDS

- A20 Direct Operation of Solid Oxide Fuel Cells (SOFCs) on Natural Gas
- A21 Non-vacuum Thin-film Photovoltaics (PV) Processes
- A21 The Use of Solid Oxide Membranes in Power Generation Applications
- A22 Two-Phase Flow Turbine for Co-Generation, Geothermal, Solar and Other Applications

- A22 Cost Effective, Low Distortion, Adjustable Speed Drives
- A23 Composite Architectures for Sub-600°C Solid Oxide Fuel Cells
- A24 Energy Production from Bulk Wastewater Using Optimized Supersynthetic Bacteria
- A24 Development of a Borehole Seismic Receiver Array for Geothermal Wells
- A25 Anaerobic Pump
- A25 High-Efficiency Single Phase Air Conditioner

SOLICITATION 00-01 AWARDS

- A26 Closed-Cycle Valved Cell Heat Engine
- A26 Single Crystal Silicon Sheet Growth
- A27 AGF Pasteurization Process Assessment, Orange County, CA
- A27 Carbon Foam Based NOx Biofilter
- A27 Corrosion Resistant Coating for Carbonate Fuel Cell Components
- A28 Biomass Boundary Layer Turbine Power System
- A28 Improved Performance of Energy Recovery Ventilators Using Advanced Porous Heat Transfer Media

SOLICITATION 00-02 AWARDS

- A29 Proposal to Research Energy-Efficient Designs for Swimming Pool Pump Systems
- A30 Counter Rotating Wind Turbine System
- A30 Increasing Efficiency of Geothermal Energy Generation with High Resolution Seismic Imaging
- A30 Distributed Generation Drivetrain for Windpower Application
- A31 Energy-Efficient Air-Handling Controls
- A31 Omni-Directional Insect Eye Concentrator Using A Hyper-Spectral Photovoltaic Cavity Converter (PVCC)
- A32 Research on Manufacturing Quadruple-Junction Solar Cells
- A32 Highly Conductive, Water Insoluble & Thermally Stable Proton Exchange Membrane (PEM) from Functionalized Polyoxometalates (POMs)
- A33 Evaluation of a New Solar Air-Conditioning System
- A33 Development of Optimum Design Configuration and Performance for Vertical Axis Wind Turbine
- A34 Commercial and Residential Super Insulated Phase Change Material Water Heater

Projects Funded through the PIER Program Areas – IN-PROGRESS

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

- A35 Energy Efficient Downlights for California Kitchens
- A35 Increased Energy Efficiency of Air Conditioners through Use of Advanced Power Electronics
- A36 Development of an Advanced Indirect Evaporative Heat Exchanger Module
- A37 Conceptual Design Energy Analysis Tool
- A37 Alternatives to Compressor Cooling, Phase V
- A38 HVAC Distribution Systems In Commercial Buildings
- A38 Building Specification Guidelines for Energy Efficiency
- A39 Design Refinement and Demonstration of a Market-Optimized Residential Heat-Pump Water Heater
- A39 Removing the Key Technical Barrier to the Widespread Use of Advanced Absorption Cooling
- A40 Improving Energy Efficiency of Commercial Kitchen Exhaust Systems
- A40 Next-Generation Power Management User Interface for Office Equipment
- A41 Instrumented Home Energy Rating and Commissioning
- A41 Investigation of Secondary Loop Supermarket Refrigeration Systems
- A42 Center for the Built Environment (CBE)
- A43 Energy Efficient and Affordable Small Commercial and Residential Buildings Program
- A43 Integrated Energy Systems Productivity and Building Science Program

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

- A45 Recycling Chiller-Bath Rinse Water in Poultry Processing
- A45 Energy Efficient Agricultural Technologies
- A46 Target 23/2.6 Chemicals, Petroleum and Natural Gas
- A47 Target 35/6 Customer Power Conditioning Solutions
- A48 Target 38/10 Power Quality for Improved Industrial Operations
- A50 Industrial Waste Processing (#825)
- A50 High Efficiency Steam Generation (#1218)

RENEWABLE ENERGY TECHNOLOGIES

- A52 Next Generation Wind Turbine Development Project
- A52 Development of an Extended Induction Logging Tool for Geothermal Exploration and Field Development
- A53 Design and Optimization of a Solar-fired Double-effect Absorption Chiller
- A54 PowerWheel Demonstration Project
- A54 Natural Gas Cofiring in Biomass Boilers
- A55 Collins Pine Cogeneration Project
- A56 Powertherm, A Photovoltaic/Thermal Hybrid Commercial Roofing System
- A57 Residential Electric Power Security
- A58 Hybrid Solar-Fossil Thermophotovoltaics
- A58 Powerguard® PV System Advanced Manufacturing Development and Scale-Up
- A59 Utilization of Waste Renewable Fuels in Boilers with Minimization of Pollutant Emissions
- A60 Cofund 59, California Wind Energy Forecasting System Development and Testing

ENVIRONMENTALLY-PREFERRED ADVANCED GENERATION

- A62 Solid-Oxide Fuel Cell/Micro Turbine Generation Hybrid
- A62 Low NOx Gas Turbine Combustors for Distributed Power Generation
- A63 Durability of Catalytic Combustion Systems
- A63 A Novel Steam Reforming Reactor for Fuel Cell Distributed Power Generation
- A64 75-kW Molten-Carbonate Fuel Cell (MCFC) Stack Verification Test
- A64 Energy Efficient, Low Emission, Cost Effective MicroPilot Ignited Natural Gas Engine Driven Genset for Deregulated, Distributed Power Generation Markets
- A65 Catalytic Combustor-Fired Gas Turbine for Distributed Power and Cogeneration Applications
- A66 Targets 63.0/23 Emerging Distributed Resource Technologies; 63.1 IC Engine Development for DR Applications; 63.4 Fuel Cell Distributed Power Systems
- A67 Targets: 87.0 Hydropower Operations, Relicensing and Environmental Issues; 87.1/48 Environmental Issues Management
- A68 Target 103/44 Fish Protection Issues
- A69 Advanced Fuel Cells (#165)

ENERGY-RELATED ENVIRONMENTAL RESEARCH

- A70 Golden Eagles in a Perilous Landscape: Tracking the Effects of Mitigation for Energy Based Mortality
- A71 Global Climate Change - California Implications and Potential Costs
- A71 Electrotechnology Applications for Potable Water Production and Protection of the Environment
- A72 Central Valley Ozone Study
- A73 Target 43 Water Quality Criteria and Toxics in Aquatic Environments
- A72 Target 105/46 Facilities Water Management

STRATEGIC ENERGY RESEARCH

- A75 Electric System Seismic Safety and Reliability
- A75 Development of a Real-Time Monitoring Dynamic Rating System for Overhead Lines
- A76 2 kWh Flywheel Energy Storage System
- A76 Light Activated Surge Protection Thyristor (LASPT) for Distribution System Reliability

- A77 Intelligent Software Agents for Control & Scheduling of Distributed Generation
- A77 Sagging Line Mitigator (SLIM)
- A78 Electric System Seismic Safety and Reliability
- A78 Electric System Reliability Enhancements
- A79 Target 57/30 Grid Planning & Development
- A80 Targets: 64/24 Distributed Resources (DR) Information and Tools for Business Strategy Development
- A81 Distributed Generation (#733)

Projects Funded through the Energy Innovations Small Grant Programs – IN-PROGRESS

SOLICITATION 99-01 AWARDS

- A83 Electrosynthesis of Device Quality Semiconductor Films
- A83 Ventilation Measurement and Control
- A84 Control of On-Off Equipment in Buildings
- A84 Process for Converting Sewage Sludge and Municipal Solid Wastes to Clean Fuels
- A85 New Generation Thermoelectric Materials for Power Generation and Refrigeration
- A85 Renewable Hydrogen Fuel Production by Microalgal Photosynthesis
- A86 Roofing Tile for Natural Cooling
- A86 Modeling Greenhouse Temperature for Energy Efficient Production
- A86 A New Gas Turbine Engine Concept for Electricity Generation with Increased Efficiency and Power
- A87 Development and Characterization of Improved Solid State Dye-Sensitized Nanocrystalline Solar Cells
- A87 Actively Controlled Jet Injection in Gas Turbine Engines
- A88 Omni Smartpump
- A88 High Speed Light Activated On/Off Thyristor

SOLICITATION 99-02 AWARDS

- A89 Improved Operational Turndown of an Ultra-Low Emission Gas Turbine Combustor
- A89 Low Cost Microchannel Reformer for Hydrogen Production from Natural Gas
- A90 Feasibility of Solar Fired, Compressor Assisted Absorption Chillers
- A90 Energy Shaver – A Thermal Energy Storage Device for Air Conditioners

Projects Funded through the PIER Program Areas – COMPLETED

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

- A92 Evaluate Small Commercial Air Conditioning Units for Northern/Central California
- A92 Improve the Cost Effectiveness of Building Commissioning Using New Techniques for Measurement, Verification and Analysis
- A93 Improve the Cost effectiveness of Building Control Systems Sensing and Data Collection
- A93 Residential Thermal Distribution Systems
- A94 Commercial Thermal Distribution Systems
- A95 Diagnostics for Building Commissioning and Operations
- A95 Building Design Advisor
- A96 Alternatives to Compressor Cooling
- A97 High-Efficiency Lighting Torchieres
- A98 CIEE Collaborative Program Planning and Management
- A99 Target 1 Residential Heat Pump Technology
- A100 Target 11 Commercial Building Lighting
- A101 Commercial Cooling and Heating Pump Applications (#1417)

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

- A102 Integrated Agriculture Technology
- A103 Low Dross Aluminum Melter Project

- A103 Laboratory-Type Facilities
- A105 Target 18/2.1 Materials Fabrication
- A106 Target 19/2.2 Materials Production
- A107 Target 21/2.4 Municipal Water and Wastewater
- A108 Target 22/2.5 Food Processing
- A109 Target 26/2.5 Agriculture
- A110 Target 27 Electronics Industry

RENEWABLE ENERGY TECHNOLOGIES

- A111 Photovoltaic (PV) Chargeport Demonstration
- A111 Photovoltaics
- A112 Solar Two
- A113 Secondary Distribution System Impacts of Residential EV Charging
- A113 Target 66/53 Renewable Technology Options and Green Power

ENVIRONMENTALLY PREFERRED ADVANCED GENERATION

- A115 Distributed Resources Demonstration
- A115 Fuel Cell Development and Demonstration
- A116 Solid-Oxide Fuel Cell/Micro Turbine Generation Hybrid
- A117 Micro-Turbine Generator (Distributed Generation)
- A117 A Novel Steam Reforming Reactor for Fuel Cell Distributed Power Generation
- A118 75-kW Molten-Carbonate Fuel Cell (MCFC) Stack Verification Test
- A119 Analyses and Technology Transfer for Fuel Cells

ENERGY-RELATED ENVIRONMENTAL RESEARCH PROGRAM AREA

- A120 Regional Ambient Aerosol Studies (RAAS)
- A121 Bird Strike Monitor
- A121 Avian Powerline Interaction Committee
- A122 Food Service Technology Center
- A123 Wildlife Interactions with Utility Facilities
- A124 Trenchless Burial Equipment
- A125 Water and Wastewater Electrotechnologies
- A126 Habitat and Species Protection
- A126 Desert and Mountain Air Transport
- A127 Formation of NO_x in Industrial Gas Burners
- A128 Target 97, Groundwater and Combustion By-Products Management
- A129 Target 107 Plant Multimedia Toxics Characterization (PISCES)

STRATEGIC ENERGY RESEARCH

- A131 Electric System Seismic Safety and Reliability
- A131 Dynamic Circuit Thermal Line Rating (DCTR)
- A132 System Stability and Reliability: Flexible AC Transmission Systems (FACTS) Benefits Study
- A132 Phasor Measurement Units
- A133 USAT MOD-2
- A134 Energy Source Stabilizer (ESS)
- A134 Substation Reliability
- A135 Development of a Composite Reinforced Aluminum Conductor
- A136 Target 1 Residential Heat Pump Technology
- A137 Target 7 Commercial Heat Pump/Air Conditioning Technology
- A138 Target 9 Commercial Building Thermal Storage
- A138 Target 28/3 Airport Solutions
- A140 Target 41 Opportunities in Networked Home Services
- A141 Target 49/13 Power Markets and Risk Management
- A142 Target 56/29 Grid Operations & Management
- A143 Target 61 Knowledge-Based Customer Metering; 61.1 Technology Development; and 61.2 Market Research and Services Development
- A144 Target 91, Air Toxics Health and Risk Assessment

PROJECTS FUNDED IN 2000 THROUGH THE PIER PROGRAM AREAS

Residential and Commercial Buildings

End-Use Energy Efficiency

COFUND 50, DEVELOPING AN R&D PLAN FOR THE PIER BUILDINGS TEAM TO ADDRESS INDOOR AIR QUALITY IN CALIFORNIA BUILDINGS

Contract #: 100-98-001

Contractor and Major Sub-Contractors: EPRI; Taylor Engineering, the Building Ecology Research Group, Lawrence Berkeley Laboratories (LBL), and National Institute of Standards and Technology (NIST).

CEC Project Amount: 2000: \$269,000

Match Funding: \$0

Contractor Project Manager: Mukesh Khattar

Commission Project Manager: Nancy Jenkins

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to develop a comprehensive indoor air quality (IAQ) research plan, identify important gaps in this research as they pertain specifically to energy efficiency, target areas for future funding and research, and prioritize research efforts that will specifically benefit California residents. Almost 70% of the California workforce works in non-industrial, non-agricultural indoor settings. Over the past 20 years, it has become clear that improper design, operation, and maintenance of HVAC systems have been implicated in infectious or allergic healthcare problems including increased frequency of colds and flu, hypersensitivity pneumonitis, sick building syndrome, and Legionnaires' disease. This project addresses IAQ through an interdisciplinary approach, uniting experts from several fields of study.

This project contributes to the PIER program objectives of:

- Improving energy cost/value through optimizing the use of building HVAC systems and improving occupant health, productivity and comfort.
- Improving the environment and public health costs/risks of California's electricity by identifying key areas of research to mitigate IAQ-related illness and loss of worker productivity.

Proposed Outcomes:

1. Identification of the highest priority research needs pertaining to the relationship of IAQ, health, occupant

satisfaction, and worker performance with building energy use.

Project Status: The project is behind schedule and continuation is uncertain due to organizational changes at EPRI.

HIGH PERFORMANCE COMMERCIAL BUILDING SYSTEMS PROGRAM

Contract #: 400-99-012

Contractor and Major Subcontractors: Lawrence Berkeley National Laboratory (LBNL) and Texas A&M University (TAMU), Massachusetts Institute of Technology (MIT), University of California, San Diego (UCSD), University of California, Berkeley (UCB), Davis Energy Group (DEG).

Contract amount: \$1,988,155 (1999/00)
\$1,999,074 (2000/01)
\$1,988,155 (2001/02)

Total Contract: \$5,995,000

Total Match: \$3,093,000

Contractor Project Manager: Stephen Selkowitz
(510) 486-5064

Commission Contract Manager: Martha Brook
(916) 654-4086

Project Description: The purpose of the High Performance Commercial Building Systems Program is to develop and deploy a set of energy savings technologies, strategies, and techniques to help improve processes for designing, commissioning, and operating commercial buildings. The goal of this program is to reduce energy use in the California commercial sector by 22 percent by 2015. An important related goal is to provide significant economic benefits to building owners and health and performance benefits to occupants. At the same time this program will strengthen the growing energy efficiency industry in California by providing new jobs and growth opportunities for companies providing the technology, systems, software, design, and building services to the commercial sector.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by helping customers optimize their building systems to perform at peak efficiency; and

- Improve the reliability/quality of California's electricity by helping lower peak electrical demand from California's commercial building sector.

Project Status: The contract began in July 2000. Preliminary research products are within budget and on schedule. A public web site (<http://buildings.lbl.gov/cec/>) has been established for this research program.

AIR CONDITIONING AND REFRIGERATION TECHNOLOGY INSTITUTE (ARTI) MEMBERSHIP

Contract #: 400-99-014

Contractor: Air Conditioning and Refrigeration Technology Institute (ARTI)

Contract Amount: \$300,000

Contractor Project Manager: Glenn Hourahan (703) 524-8800

CEC Contract Manager: Brad Meister (916) 653-1594

Project Description: Membership in ARTI allows the Commission to leverage public benefit research dollar expenditures for maximum benefit by combining Commission funding with that of other members to support specific research as well as developing and implementing public interest RD&D policies and programs that encourage well-functioning energy markets through advancements in science and pre-competitive technology that promise to enhance California's economy and/or environment.

The targeted subcommittees (focus areas) selected by Commission staff for research and development funding are:

- Equipment Energy Efficiency
- System Integration
- Indoor Environmental Quality

As a result of membership participation in ARTI, the California Energy Commission realizes the following benefits:

- Participate, as a voting member of the ARTI 21-CR Steering Committee and as such, may be involved in all tasks of the Committee. The Steering Committee directs the overall effort, establishes procedures, assigns priorities and approves projects for support. The CEC may target up to 50% of Commission-provided funding for those specific research projects, which the Commission determines to have the greatest potential for reducing energy consumption.
- Participate in the 21-CR subcommittee meetings, as agreed with the subcommittee chairs, and receive minutes of subcommittee meetings as requested. The subcommittees identify and prioritize research needs and provide recommendations to the Steering Committee. In

addition, the subcommittees will make contractor selections and monitor research progress.

- Receive quarterly reports and all items sent to the Steering Committee. These items may include status reports of ongoing research projects, notices of planned site visits to contractor meetings, and draft research reports.
- Access to all research deliverables prior to public release and on-line communication services via the ARTI web site. These deliverables may include reports, analytical tools, databases and other products developed in the research projects.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of CA's electricity system during peak load times by helping improve air conditioning system efficiency.
- Improving environmental and public health cost/risks of California's electricity by reducing harmful NO_x emissions and CO₂ emissions resulting from electricity generation.
- Maximizing California's market/economy connection because approximately one in eight of all air conditioners manufactured by ARTI members are shipped to California. California is the biggest market for air conditioners in the country, and improvements in the technology will directly benefit California's electric customers.

Project Status: The contract was approved November 30, 2000. Work is continuing and the next Steering Committee Meeting is in April 2001.

CHARACTERIZATION OF FRAMING FACTORS FOR NEW LOW-RISE RESIDENTIAL BUILDING ENVELOPE

Contract #: 400-00-002

Contractor and Major Sub-contractors: Enermodal Engineering Inc., R. Chitwood.

Contract Amount: \$61,000

Match Funding: \$85,810 (ASHRAE)

Contract Project Manager: Steve Carpenter, Chris Schumacher (519) 743-8778, (303) 861-2070

Commission Contract Manager: Jon Leber (916) 654-4012

Project Description: The purpose of this project is to improve understanding of heat transfer characteristics of residential wood frame walls specific to California climates and to develop a technique for accounting for the effects of California framing methods on wall heat transfer. This contract will provide improved understanding of the interaction of heat flow through the building envelope with differing framing practices.

This project supports the PIER objective of:

- Improving the reliability/quality of California's electricity by helping to build more energy-efficient homes that will help reduce electric demand.

Project Status: Framing data collection surveys are finished. Summary of results is scheduled to be available by end of March 2001. Analysis of survey results has started. Analysis schedule to be completed by end of April 2001.

Industrial / Agricultural / Water End-Use Energy Efficiency

AGRICULTURE ENERGY END-USE EFFICIENCY

Contract #: 400-99-014

Agency Partners: California Polytechnic State University, San Luis Obispo

Commission Funding: \$1,500,000

UCD Project Manager: Dr. Charles Burt (805) 756-2379

Commission Project Manager: Ricardo Amon (916) 654-4019

Project Description: The purpose of this program is to improve the energy efficiency in the transportation, delivery, and utilization of agricultural water provided by irrigation districts. Until the infrastructure of the irrigation districts are adequately addressed, most sophisticated on-farm irrigation technologies such as precise irrigation scheduling, fertigation, and automated irrigation systems will not be widely adopted by farmers. This project will research and help develop and implement certain technologies to improve water-use efficiency. Power quality, which is a related issue, will also be researched as it impacts the irrigation districts.

California Polytechnic will perform the following tasks:

- Document implementation of new technologies;
- Develop a simple procedure for tuning controller constants for automatic upstream control of canal check structures;
- Develop new devices for volumetric metering of delivered water - trash shedding propeller meters resistant to plugging or tangling moss;
- Test and evaluate new electronic technologies for volumetric metering of delivered water such as Magnetic Meters, Ultrasonic Meters (Doppler), Vortex Shedding Meters and Ultrasonic Flow-Measurement Meters;
- Develop strategies for energy-efficient transition from low pressure non-reinforced concrete pipe; and
- Verify power quality measurement and conditioning methods.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficiency of emerging electrotechnology applications in agriculture; and
- Improving the environmental and public health costs/risks of California's electricity by replacing toxic chemicals used in agribusiness with cleaner electrotechnologies.

Project Status: Work has begun and the project is progressing well. The project is on schedule, within budget and expected to achieve the proposed outcomes.

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (MWD)

Contract #: 400-00-013

Contractor: Metropolitan Water District of Southern California

Partners: Alameda County Water District; Orange County Water District; San Diego County Water Authority; Santa Clara Valley Water District; Sonoma County Water Agency; University of California, Los Angeles; University of California, Riverside; and West Basin Municipal Water District

Contract Funding: PIER: \$2,000,000
Match: \$3,013,688
Total: \$5,013,688

Project Description: The purpose of this contract is to co-fund the full-scale demonstration and refinement of newly developed electro-technologies for producing potable and non-potable water. These technologies remove salinity and disinfect various source waters (i.e. Colorado River water, brackish ground water, municipal wastewater, and agricultural drainage water). The Energy Commission partially funded development of these technologies through PIER Transition Funding (\$410,000- 1997) and PIER I Funding (\$1,200,000- 1998).

Specific Project Objectives:

- Demonstration of new and large-scale electro-technologies that reduce the energy requirement and cost of producing potable water,
- Partnership with industry to ensure the commercial implementation of newly developed treatment technologies,
- Reducing the need for energy-intensive water imports through technologies allowing development of local, non-traditional water supplies.

Anticipated Benefits to the State of California:

- Electric utility ratepayers would benefit from reduced energy used to transport and product high quality potable water in the region. Total energy savings are estimated to be 12,000 gigawatt-hours (GWh) over 20 years,
- Additional development of local water supplies could partially offset the need to import water from outside the region, reducing pumping costs and energy usage. The results generated from this study may result in 7,000,000 acre-feet of additional potable water for California,
- Savings from developing local supplies are estimated to be in excess of \$140 million, and
- Savings from avoiding salinity damages to commercial, industrial, and residential property are estimated to be in excess of \$500 million.

Contract Status: The term of this contract is from January 15, 2001 to July 31, 2003. The Contractor has the contract for approval and signatures.

ENERGY-EFFICIENT LABORATORIES AND CLEANROOMS FOR HIGH-TECH INDUSTRIES

Contract #: 400-00-020

Contractor and Major Sub-contractors: Lawrence Berkeley Laboratory (LBNL), Northwest Energy Efficiency Alliance, U.S. DOE, ASHRAE, SEMATECH, Major Energy Users Group (MEUG), Northwest Energy Efficiency Alliance (NEEA), EPA/FEMP Laboratories for the 21st Century, University of California and California State University System.

Contract Amount: \$352,000

Match Funding: \$125,000 (USDOE \$50,000; NEEA \$75,000)

Contract Project Manager: Dale Sartor (510) 486-5988

Commission Contract Manager: Clint Lowell
(916) 654-4554

Project Description: The purpose of this project is to develop resources and tools to help cleanroom and laboratory facility designers and operators achieve a 50 percent reduction in energy use. The project includes the development of a Cleanroom Facility Planning Guide, completion of the development of a Laboratory Design Intent Tool, performance evaluation and design improvements of a low-flow fume hood, and the development of a more comprehensive roadmap to identify additional research needs for high-tech buildings.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of California's electricity by developing methods for reducing energy use and peak demand in a high-use energy sector; and
- Improving the cost/value of California's energy by increasing the competitive position of California's high-tech industries.

Project Status: Contract negotiations continued into 2001. This project is expected to begin in March 2001.

Renewable Energy Technologies

COFUND 58, CALIFORNIA RENEWABLE ENERGY TECHNOLOGY MARKET AND BENEFIT ASSESSMENT

Contract #: 100-98-001

Contractor and Major Sub-Contractors: EPRI; Global Energy Concepts

CEC Project Amount: 2000: \$340,352

Contractor Project Manager: Chuck McGowin

Commission Project Manager: George Simons

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to develop an understanding of the current and future performance and costs of renewable energy technologies and resources in California. The project encompasses a multi-phase program that will complement the market analysis performed by the Renewable Energy Program and quantify the benefits of renewable energy research and development (R&D) programs. It also addresses technological issues confronting the manufacturers and developers of renewable energy systems in California. Project results will include renewable resource maps of California, descriptions of renewable energy technologies and their status, market assessments, likely development pathways, current and projected cost and performance, potential for quantified environmental benefits, descriptions of evolving markets and service, and data on key customers and players in the industry. Renewable energy technologies to be addressed include biomass and waste fuels, geothermal, small hydro, solar photovoltaic, solar thermal, wind power, and ocean or tidal current power.

This project contributes to the PIER program objectives of:

- Improving energy cost/value by helping make renewable electricity more affordable, cleaner, reliable, and secure.
- Improving the reliability/quality of California's electric system by identifying issues with a direct impact on research, development and demonstration cost-competitiveness, reliability, dispatchability, and power quality.
- Strengthening the California economy by analyzing market trends, quantifying benefits, and identifying important manufacturers, developers and projects.
- Improving the environmental and public health costs/risks of California's electricity by increasing the proportion of environmentally clean renewable technology in the California energy mix.

Proposed Outcomes:

- Identify the current status of renewable technology in California, including the type, location, capacity, duty cycle and operating characteristics of renewable energy generation current deployed in the state.
- Identify the total market size of each technology in California and how it is affected by regulatory and policy issues such as air quality, utility deregulation, green markets, recovery of stranded costs, and federal tax credits.
- Assess the economics of renewable energy generation.
- Identify potential new players in California's renewable energy marketplace.
- Characterize the technologies most likely to succeed in both large- and small-scale markets.
- Quantify renewable energy benefits and summarize market data.

Project Status: The final report has been drafted.

Publication of the final report is now scheduled for April 2001.

ACCELERATED LIGNIN TESTS FOR BIOMASS POWER PLANTS

Contract #: 500-99-027

Contractor and Major Sub-Contractors: Ogden Power Pacific, Inc., Pacific Oroville Power, Inc.(POPI), BC International (BCI), Energy Environmental Research Center (EERC)

Contract Amount: \$500,000

Match Funding: \$785,452 (NREL, USDOE, and BCI)

Contractor Project Manager: Paul Wood (POPI), Norm Hinman (BCI), Michael Green (EERC)

Commission Contract Manager: Zhiqin Zhang,
Valentino Tiangco (916) 654-4063

Project Description: This purpose of this project is to demonstrate the suitability of rice straw and wood lignin byproducts from ethanol plants for use as fuel to a boiler for steam and power production. This project builds off the previous efforts in the Gridley rice straw-to-ethanol project and the Collins Pine Co-generation project. The facility will be located at the Pacific Oroville Power, Inc. (POPI), a 16.5 MW biomass power plant owned by Ogden Power Pacific, Inc. BC International (BCI), a key contract for both Gridley and Collins Pine projects, will utilize its Jennings, Louisiana pilot to produce qualities of wood lignin and rice straw lignin required by the Ogden project.

The goal of this project is to test the technical feasibility and suitability of wood and rice straw lignin as boiler fuel for a full-scale, biomass-fueled boiler and to identify and design any modifications to the boiler and other equipment to accommodate the use of lignin. The specific technical performance objective for this project is to define the engineering modifications to POPI steam and power production that will accommodate the use of 100 percent of the lignin produced by the ethanol plant. The specific economic performance objective for this project is to reduce the cost of electricity production at POPI by at least 1.5 cents/kWh.

The project will provide environmental benefits include reduction in open-field agricultural burning, reduction in risk of wild fires, decreased emissions from rice straw and forest burning, improvement in forest health and increased diversity of electric generation. The project will also address the public concern over the growing evidence that methyl tertiary-butyl ether (MTBE) in gasoline is contaminating California's ground water and surface water and support on-going efforts to evaluation options for the replacement of MTBE using ethanol in California. The results from the project will help operating biomass power plants retain an important element of the distributed power capability in California.

The specific technical objectives for this project are to:

- Characterize the quantity and form of inorganic constituents in lignin in an attempt to link lignin residue properties to boiler performance.
- Conduct bench scale and pilot scale combustion testing to determine effects of lignin on: a) the sticking potential of boiler ash to heat transfer surfaces; b) slagging and agglomeration potential of the ash near the burner or grate regions of the boiler; c) convective surface fouling potential as determined by deposit strength, removability, chemistry, porosity, and liquid phase viscosity; d) combustion reactivity and charburnout characteristics; e) particulate control characteristics; and f) air emissions including NO_x and SO_x.
- Conduct test burns with the POPI boiler, using varying mixtures of wood and lignin.
- Conduct tests to evaluate the handling, conveying and storage characteristics of lignin.
- Conduct tests to evaluate handling, conveying and storage of ash.
- Define engineering modifications to the Oroville boiler and/or other equipment needed to accommodate the use of lignin.
- Evaluate requirements for environmental, construction and operating permits.

This project contributes to the PIER program objective of:

- Improving the reliability/quality of California's electricity system by continuing the development and improvement of renewable biomass energy power plants;
- Improving the energy cost/value of California's electricity by continuing to improve biomass power plant development for distributed generation; and
- Maximizing market/economy connection by providing the results from this project to the biomass industry and improving the cost competitiveness of California's biomass energy conversion technology.

Project Status:

- Kickoff Meeting on this project was held on November 28, 2000 at Pacific Oroville Power plant site in Oroville, California.
- BCI provided documentation of BCI cost share to CEC-Ogden contract. Ogden and/or BCI will provide cost share funds in the following amounts: 1) \$633,952 (BCI and NREL) for lignin production; and 2) \$151,500 (NREL/USDOE) to support the lignin test program.
- The project was originally scheduled from 8/14/00 to 11/5/00. No progress report and invoices have been received in this project yet. Effort is being done modify the schedule. Contractor was reminded on their deliverables and monthly progress reports.

RESEARCH, DEVELOP AND DEMONSTRATE 12 KW SMALL MODULAR BIOPOWER SYSTEM

Contract #: 500-99-029

Contractor and Major Subcontractors: Community Power Corporation, Shell International Renewables, and National Renewable Energy Laboratory

Contract Amount: \$645,827

Match Funding: \$609,695

Contractor Project Manager: Robb Walt (303) 933-3135

Commission Contract Manager: Prab S. Sethi, P.E.
(916) 654-4509

Project Description: The overall goal of this project is to design, develop and demonstrate a stand-alone small modular biopower (SMB) system (12 kW) for a distributed generation application providing both electricity and heat using two different species of forest residue.

This project is Phase II of SMB initiative co-funded by the National Renewable Energy Laboratory (NREL)/US Department of Energy (US DOE). In this Phase II, Contractor shall design, fabricate and test two SMB systems; namely NREL SMB and PIER SMB. NREL SMB is funded by NREL/US DOE and Contractor's strategic partner, Shell International Renewables, Ltd for rural electrification project in the Philippines. PIER SMB is

funded by PIER and co-funded by NREL/US DOE. Contractor shall design, fabricate and test PIER SMB, based from lessons learned in NREL SMB, for combined power and heat application at Tsemeta Forest Regeneration Complex, Hoopa, California. Phase I of SMB initiative is a feasibility stage, completed and funded by mainly by NREL/US DOE and not PIER funds.

This Phase II project supports the PIER program objectives of improving cost competitiveness of the biomass energy conversion technologies and reducing environmental risks and costs of California's electricity. This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts and reducing environmental risks. If successful, this technology will provide beneficial means of forest residue disposal, reduce wildfires, and reduce air pollution from in-forest burning of slash; and
- Improving the reliability/quality of California's electricity by removing barriers to distributed generation technology.

Proposed Technical Outcomes: The overall technical objective of this project is to develop and demonstrate a 12 kW small modular biopower system in a displaced retail, combined heat and power application, and collect the data needed to develop the scale-up path to a family of commercially viable systems in California.

The specific technical objectives are:

- Provide up to 12.5 kilowatt electric (kW_e) and 20 kilowatt thermal (kW_t) power to the proposed on-site load
- Provide 220 volts, 3 phase power for the proposed load in parallel with the grid
- Operate with no more than one operator
- Provide 12.5 kW_e power using two of the following feedstocks: Oak, Alder, Madrone and/or Douglass Fir
- Incorporate system improvements based upon data collected during operation
- Translate operating performance of a 12 kW system into clear technical requirements for development of a family of small modular biopower systems between 12 kW and 500 kW
- Achieve combined heat and power efficiencies of greater than 60 percent. Electrical efficiency to be no less than 18,000 Btu/kWh (higher heating value (HHV))

- At peak power of 12.5kW_e, the small modular biomass (SMB) system will meet or exceed California's emission standards for a 4 cylinder automobile internal combustion engine. Nitrogen oxides (NO_x) emissions of engine no greater than 1,500 ppm (at full load, 3% O₂). Particulate matter (PM) emissions no greater than 5 ppm.

Proposed Economic Outcomes: The overall economic objective of this project is to achieve competitive financial performance for a family of distributed generation applications of the SMB system, both on-grid and off-grid.

The specific, economic/cost objectives for the minimum and maximum size ranges are shown below. This assumes the global sales of SMB system of 1000 units a year.

- 500 kW (grid-connected)
 - capital cost of \$600 per kW
 - electricity cost of less than 7 cents per kWh
 - heat cost less than \$0.70 per therm
- 12 kW (grid-connected and off-grid)
 - capital cost of \$1,000 per kW
 - electricity cost of less than 15 cents per kWh
 - heat cost less than \$1.20 per therm

Project Status: The project kick-off meeting was held at Hoopa Valley on November 1, 2000. The Commission Contract Manager (Prab S. Sethi), Commission Contract Officer (Judith Eghan), Community Power Corporation (Robb Walt), and Robert Ulibarri (Hoopa Valley Tribe) attended this meeting.

- Task 2.1 Develop, Install and Operate NREL-SMB:
 - The work related to shakedown testing of the first small modular biopower system developed under Phase 2 contract with NREL was completed. 125 hours of run time, 28 start-stop cycles and 780 kWh were generated. The unit was shipped to Philippines in February 2001.
- Task 2.4 Build/test PIER-SMB (Test Bed):
 - Preliminary layout of the SMB system at the Hoopa Forest Regeneration Complex has been completed.

Environmentally-Preferred Advanced Generation

MICROTURBINE GENERATORS, FUEL CELLS AND HYBRID SYSTEMS DEVELOPMENT

Contract #: 500-99-028

Contractor: University of California, Irvine

Contract Amount: \$1,409,177

Contractor Project Manager:

CEC Contract Manager: Art Soinski (916) 654-4674

Project Description: The purpose of this project is to develop standardized testing and reporting procedures for microturbine generators (MTGs), develop steady-state analytical tools for fuel cells, and develop dynamic modeling capabilities for fuel cell and fuel cell/turbine hybrid systems. When completed, these three projects will help provide greater choice for California ratepayers in their selection of electric supply options.

The economic performance goals of the projects are to:

- Accelerate the market penetration of environmentally sensitive power generation technologies
- Reduce the cost of electricity, and
- Increase electricity availability and reliability at a lower technology development cost by replacing physical experimentation with less expensive computer modeling.

These projects support the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing reliable alternatives for distributed generation applications that are not grid-dependent;
- Improving the cost/value of California's electricity by developing energy technologies that will reduce the cost of transmitting and distributing electricity;
- Improving the environmental and public health costs/risks of California's electricity by providing reliable, energy-efficient, low-emission electricity-producing technologies; and
- Expanding consumer choice by developing alternatives to grid-supplied electricity.

Proposed Outcomes: Standardized testing and reporting procedures for MTGs will:

- Provide consistent MTG performance information regardless of who performs the testing;
- Allow comparison between manufacturer specifications and actual operation; and
- Identify critical technology barriers limiting performance of these devices and thereby identify opportunities for future research and development efforts.

Steady-state analytical tools for fuel cells will:

- Develop and document the use of steady state simulations that permit the analyses of fuel cell systems and hybrid cycles and their performance;
- Develop a Standardized Analysis Format that is accepted by fuel cell, turbine, and hybrid manufacturers and developers; and
- Establish a Internet-based public information tutorial.

Fuel Cell Hybrid Dynamic Modeling will:

- Develop a standard framework for the dynamic simulation of hybrid fuel cell/turbine systems;
- Develop simulation capabilities for modeling: (1) a reformer, (2) a solid oxide fuel cell, (3) a gas turbine engine, (4) hybrid balance of plant components, and (5) a molten carbonate fuel cell;
- Acquire data for model verification;
- Validate the modeling tools, including model comparison to data from a specific hybrid solid oxide fuel cell-microturbine generator (SOFC-MTG) system; and
- Broaden the modeling capabilities to assist in the development of second-generation hybrid systems (e.g., SOFC-GT) and new types of hybrid systems, specifically the molten carbonate fuel cell-gas turbine (MCFC-GT).

Project Status: The project is on schedule, within budget and expected to meet the proposed outcomes.

DESIGN, DEVELOP AND DEMONSTRATE SMALL MODULAR FLEX-MICROTURBINE THAT WILL RUN ON LOW-ENERGY AND LOW-PRESSURE BIOMASS GASES.

Contract #: 500-99-030

Contractor and Major Subcontractors: FlexEnergy, Inc., Capstone Turbine Corporation, National Renewable Energy Laboratory, and University of California, Davis

Contract Amount: \$983,653

Match Funding: \$2,546,035

Contractor Project Manager: Edan Prabhu
(949) 380-4899

Commission Contract Manager: Prab S. Sethi, P.E.
(916) 654-4509

Project Description: The overall goal of this project is to design, develop and demonstrate a Flex-Microturbine™ that will run on different biomass fuels; namely, biogas generated from anaerobic digestion of livestock manure, producer gas generated from thermal gasification of

orchard and forest residues, and biogas from landfill gas recovery system.

This project is Phase II of small modular biomass (SMB) initiative co-funded by the National Renewable Energy Laboratory (NREL)/US Department of Energy (US DOE). In this Phase II, Contractor shall design, develop and demonstrate a proof of concept (POC) and three prototypes of Flex-Microturbine™. Prototype 1 will be fueled from biogas generated from anaerobic digestion of livestock manure. Prototype 2 will be fueled from producer gas generated from thermal gasification of orchard and forest residues. Prototype 3 will be fueled from landfill gas. Prototypes 1 and 2 are funded by PIER and co-funded by NREL/US DOE. Prototype 3 is funded by NREL/US DOE only and not part of the PIER project. Phases I and IA of SMB initiative are feasibility and preliminary design stages, respectively. Phases 1 and IA are completed and funded through NREL/US DOE.

This new Flex-Microturbine™ is intended to act as safe, reliable, clean, cost-competitive provider of renewable energy with particular value to California's deregulated electricity marketplace. This project supports the PIER Program objectives of:

- Improving cost competitiveness of the biomass energy conversion technologies, and reducing costs of California's electricity;
- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts and reducing environmental risks; and
- Improving the reliability/quality of California's electricity by developing a new distributed generation technology.

Proposed Technical Outcomes: The technical objective of this project is to design, develop and demonstrate a Flex-Microturbine™ that has the ability to run on low pressure and low Btu gases from biogas generated from anaerobic digestion of livestock manure, from producer gas generated from thermal gasification of orchard and forest residues, and from biogas from landfill gas recovery system.

The specific technical performance objectives of this project are as follows:

For Proof-of-Concept (POC)

Demonstrate that fuel and air mixture of 100 Btu/scf to 800 Btu/scf can be successfully and safely mixed and used to achieve combustion in a microturbine, using natural gas as the fuel

- Attain successful combustion for 4 hours for the specified mixtures

- Measure emissions, including NO_x and hydrocarbons
- Measure temperatures, pressures, output and other pertinent performance parameters

For Prototype 1 (Digester Gas and Demonstration Unit)

- Conduct shop tests as in POC
- Demonstrate safe startup and shutdown
- Demonstrate ability to accept fuel gas at less than 0.25 psig
- Operate for 7 days on digester gas
- Ammonia-free NO_x emissions below 9 PPM (15 %O₂)
- Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV)
- Ability to load follow (operate at different loads, 20% to 80% capacity)
- Ability to handle wide variation in fuel Btu content (200 to 800 Btu/scf)

For Prototype 2 (Wood Gasifier Prototype and Demonstration Unit)

- Demonstrate capability to operate for at least 8 hours at a time for 5 days in a row
- Demonstrate ability to accept gas at below 0.25 psig
- Demonstrate safe startup and shutdown
- Demonstrate capability to run on gas with normal rated gasifier output (112 Btu/scf, 5 PPM tar, 5 PPM particulates)
- Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV)
- Ability to handle gas Btu variations (with a minimum of 100 Btu/scf)
- Ability to run on below normal gas quality (100 Btu/scf gas) for 8 hours
- Test ability to run three Flex-Microturbines running on one gasifier
- NO_x emissions below 9 PPM (@15 % O₂)
- Particulate emissions below 0.02 lb./MWH

For Prototype 3 (Landfill Gas Prototype and Demonstration Unit)

- Demonstrate safe startup and shutdown
- Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV)
- Demonstrate ability to accept gas at below 0.25 psig
- Operate continuously for 30 days
- NO_x emissions below 9 PPM (@15 % O₂)
- PM10 Particulate emissions below 0.02 lb./MWH
- Demonstrate ability to run on gases as low as than 100 Btu/scf for 24 hours

Proposed Economic Outcomes: The economic objective of this project is to develop Flex-Microturbine™ that provides cost competitive renewable energy in a deregulated electricity marketplace.

The specific economic objectives of this project in mature commercial volumes are as follows:

- The Flex-Microturbine™ will be available in price of about \$400/kW. This price assumes the global sales of microturbines over 10,000 a year.
- In landfill gas applications, where the gas is already available in most landfills in the state, power will be produced for less than \$0.03/kWh with a capacity factor of 90%.
- The entire power plant, including a manure digester, will cost about \$800/kW when about one hundred digesters are installed. Power will be produced from digester gas at about \$0.03/kWh with a capacity factor of 90% without considering the benefit of energy and environmental credits
- The portable wood gas power plant, including the gasifier, will be available for \$1000/kWh, in volumes of over one hundred a year. Power will be produced for less than \$0.05/kWh.

Project Status: The project kick-off meeting was held at the Capstone offices in Chatsworth, California on July 26, 2000. The Commission Contract Manager (Prab S. Sethi), Commission Contract Officer (Judith Eghan), Dr. Valentino Tiangco, FlexEnergy Inc. (Edan Prabhu), and Capstone Turbine corporation (George Wiltsee) attended this meeting.

Task 2.1 Proof-of-Concept: Physical design of the catalytic combustor and electrical heater has been completed. Orders were placed for purchase of catalyst sleeves, catalyst and heater. The project is on schedule and within budget.

LOW NO_x GAS TURBINE COMBUSTORS FOR DISTRIBUTED POWER GENERATION

Contract #: 500-00-002

Contractor: Alzeta Corporation

Contract Amount: \$1,311,768

Match Funding: \$2,740,000

Contractor Project Manager: Neil McDougald
(408) 727-8282

Commission Contract Manager: Dave Hatfield, P.E.
(916) 654-7119

Project Description: In a previous PIER contract (500-97-031), Alzeta Corporation designed, built, and tested a prototype combustor for micro-scale gas turbines that

produces ultra-low levels of NO_x emissions. The next steps in development funded under this contract will be to test the combustor in an operating microturbine engine and to develop prototype combustors for industrial-scale engines. Another element of the proposed work is to develop manufacturing methods that eliminate welding in the fabrication of the burner. This should have the benefit of reducing the cost of manufacturing and increase the life of the combustor. If successful, Alzeta's combustor technology will enable cost-effective reduction of NO_x emissions for even the smallest gas turbine engines. Currently many gas turbines that could be very beneficial in distributed generation service are not able to comply with air quality regulations because of the high cost of exhaust clean-up systems. Alzeta's combustor technology could enable a much broader range of options in the selection of gas turbines for distributed generation applications. This in turn would provide lower cost generation capacity, making the grid more reliable and power more affordable to California rate payers while at the same time reducing air polluting emissions.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by reducing the cost for NO_x mitigation and reduction technology for small- and micro-scale gas turbines;
- Reducing environmental and public health costs/risk of electricity generation in California by achieving greater emissions reductions than currently required by law; and
- Maximizing market/economy connection by enabling cost-effective reduction of NO_x emissions for even the smallest gas turbine engines.

Proposed Outcomes:

- Simultaneous reduction of NO_x and CO emission to less than 2 ppm (15 percent O₂) without any post combustion exhaust clean up.
- Expected cost on par with original equipment combustors.
- Eliminate the need for selective catalytic reduction (SCR) on gas turbines in non-attainment areas.

Project Status: The contract has been approved by the Department of General Services (DGS) and the Contractor has begun project work.

Energy-Related Environmental Research

PIER ENVIRONMENTAL ENERGY RESEARCH PROGRAM TECHNICAL ASSISTANCE

Contract #: 700-99-019

Contractor and Major Subcontractors: Regents of the University of California – Office of the President

Contract Amount: \$1,000,000

Contractor Project Manager: Jim Cole (510) 652-7565

Commission Contract Manager: Gina Barkalow (916) 654-4057

Project Description: The purpose of this Agreement is to obtain technical assistance to support the administration of the Public Interest Energy Research (PIER) Program in the Environmental Area. UC shall provide the services of faculty, staff, students and subcontractors to assist the California Energy Commission (CEC) in program planning, and program administration. The primary objective is the development of a PIER Environmental Area RD&D Plan (Plan). The Plan will provide a broad framework and justification for selected RD&D initiatives. The Plan will address ways of improving the scientific understanding of the adverse public health and environmental impacts attributable to the generation, transmission, and use of electricity, as well as ways of developing mitigation/enhancement strategies, tools, or technologies to address these adverse impacts.

To accomplish this work, the UC has assembled a core team. The core team is responsible for developing the Plan, as well as providing oversight and planning for the overall PIER Environmental Area. The core team will develop a process for identification, development, evaluation, and refinement of Research Development and Demonstration (RD&D) initiatives for the PIER Environmental Subject Area, including the development of comprehensive subject area research roadmaps.

Proposed Outcomes:

- Under the direction of CEC staff, identify key energy-related environmental issues that need to be addressed in the each of the four PIER Environmental Areas (air, biology, global climate change, and water).
- Identify existing environmental research efforts relative to key issues of importance to California (status of present research, proposed work, relevance to California, opportunities for collaboration).
- Identify major gaps in environmental research areas of importance to California.
- Based on tasks listed above, prepare draft PIER Environmental Area RD&D Plan.
- Obtain, incorporate, and address stakeholder review comments on the draft Plan.
- Create Planning Teams for the four subject areas (air, biology, water, and global climate change).
- Develop comprehensive subject area research roadmaps.
- Conduct workshop(s) to discuss roadmaps and projects to be developed.
- Finalize PIER Environmental Area Comprehensive Research Plan.

Actual Outcomes:

- Draft plan has been sent out to stakeholders for review comments.
- Review comments have been collated for CEC review.
- Final PIER Environmental Area RD&D Plan is expected in May.
- Planning teams for the four subject areas have been created to develop comprehensive research roadmaps.
- Comprehensive subject area research roadmaps are expected in October.

Project Status: The project is behind schedule, but within budget and expected to meet all objectives. The term of the project is to June 30, 2002.

Strategic Energy Research

ELECTRIC SYSTEM RELIABILITY ENHANCEMENTS

Contract #: 150-99-003

Agency Partners: The Consortium for Electric Reliability Technology Solutions (CERTS) which includes (the contractor) Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory (ORNL), Edison International, Power Systems Engineering Research Consortium (PSERC) and Sandia National Laboratory (SNL); Electric Power Research Institute (EPRI); California Independent System Operator (CAISO).

Commission Funding: \$4,800,000 (1999/00)
\$2,400,000 (2000/01)

DOE Match Funding: \$2,500,000 (1999)
\$2,400,000 (2000)
\$8,000,000 (2001)

LBNL Project Manager: Joe Eto (510) 486-7284

LBNL Project Contact: Rich Wilson (510) 486-7391

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Project Description: The purpose of this project is to address the transition of California's electricity supply and delivery infrastructures from vertically integrated, regulated and government-controlled organizations to desegregated, competitive market-driven institutions. Power supply, network management and control systems are being driven to find new solutions to the traditional methods used to ensure stable power flows, frequency and voltage control. This project will provide integrated research and technology development that will help produce quicker and more flexible options for meeting the reliability, stability and ancillary service needs of California's electricity consumers

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity infrastructure by finding new solutions for a continued stable power supply for a deregulated electricity market; and
- Improving the energy cost/value of California's electricity by increasing the efficiency of California's competitive electricity market.

Proposed Outcomes:

- Identify and define priorities for publicly-funded reliability research needed to support a restructured California electricity industry;
- Complete research in the area of real time system management that will allow California's interconnected

power system to operate closer to its actual physical and stability limits;

- Complete research in the area of integration of distributed resources needed to capture the full potential of distributed resources to maintain or improve the reliability of the California interconnected power system; and
- Complete research in the area of reliability and markets needed to ensure that a fair and transparent market for ancillary services will efficiently and reliably serve California energy consumers.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

DEVELOPMENT OF A COMPOSITE REINFORCED ALUMINUM CONDUCTOR

Contract #: 500-00-003

Contractor and Major Subcontractors: W. Brandt Goldsworthy & Associates, Inc.

Contract Amount: \$1,100,479

Match Funding: \$325,000

Contractor Project Manager: W. Brandt Goldsworthy
(310) 375-4565

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Project Description: The purpose of this project is to continue research begun under PIER contract number 500-98-035 with the same contractor. Under the first PIER contract, the contractor successfully completed a \$75,000 research effort to determine the feasibility of using a composite reinforced aluminum conductor (CRAC-TelePower) in applications dominated by the standard aluminum conductor, steel reinforced (ACSR), known in the industry as DRAKE conductor. This follow-on research will develop prototype manufacturing technology for CRAC and demonstrate the conductor's performance on a 2,000 foot (nominal) 3-phase span using Southern California Edison's facilities. The new conductor has advantages of higher amp loading for the same cost as DRAKE, and the potential for carrying digital and analog signals for communications and conductor diagnostic purposes.

Phase II will also evaluate manufacturing process improvement concepts which may fundamentally affect the CRAC-TelePower conductor price and quality. First example is a review of the benefits of vertical integration by installing a glassmaking furnace onsite thereby simplifying

the logistics of shipping glassfiber material to the California manufacturing plant. A second example is to review the cost savings made possible with co-mingling the glass/resin material as part of the conductor manufacturing process. A third example is to review the feasibility of individually powder coating the fibers with thermoplastic matrix material at the bushing. This idea, if proven feasible, has so much merit that it may lead to other clean manufacturing facilities in California that could supply the worldwide composites industry with a superior material system.

The goal of this project is to design, develop and demonstrate a combined transmission line power and data transfer concept. Successful demonstration of this concept also includes developing and demonstrating new manufacturing methods needed to make it cost-competitive. This technology can potentially strengthen California's and the Nation's electric power and communications infrastructure. This research supports PIER program objectives by improving the reliability of California's electricity. The research will also enable substantial environmental benefits because the technology will result in the ability to re-conductor existing lines with a conductor that transfers more power per unit of weight.

This project will improve the reliability and capability of California's transmission and distribution system by developing a stronger and lighter conductor to replace these aging and overloaded power lines. Specifically, this project will develop a composite reinforced aluminum conductor (CRAC) to replace conventional conductors made from aluminum wires wrapped over a core of steel strands (called aluminum conductor-steel reinforced (ACSR) conductors). Many miles of California's overhead electricity transmission lines have reached the end of their service lives or are being stressed beyond their design limits due to load growth and heavy power transfers across longer distances. This technical development is very timely as the current age of transmission lines ranges from 30–70 years.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup;
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors;
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines; and
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

1. Beta-test CRAC manufacturing technology by producing sufficient, specification-grade CRAC-TelePower conductor to span three phases at 2,000 feet in a real-time power transmission demonstration.
2. Demonstrate the feasibility of the CRAC-TelePower combined power and data transfer concept in a 2,000 foot, 3-phase conductor span in the Southern California Edison transmission system. Specific performance targets are:
 - Line Sag: Target is 20 % less line sag over entire operating temperature range
 - Ampacity: Target is 40 % more "Ampacity" compared to ACSR (DRAKE)
 - Magnetic Fields: Target is 50 % reduction in magnetic fields on the ground
 - Damping: Target is increased damping under conditions of galloping and aeolian vibrations
 - Data Transfer: At least 0.5°C accuracy with a spatial resolution of one meter (analog). Fewer than 1 error bits per 10⁹ bits (digital)
3. Determine the feasibility of manufacturing "CRAC-TelePower" for \$1 per product pound.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

PROJECTS FUNDED IN 2000 THROUGH THE ENERGY INNOVATIONS SMALL GRANT PROGRAM

SOLICITATION 99-03 AWARDS**Proposals Received: 70****Passed Screening: 41****SDSU Program Administrator:****Commission Program Manager:****Approved: January 26, 2000****Grants Approved: 11 (\$821,038)****Grants Funded: 9 (\$671,044)****Hal Clark (619) 594-1158****Philip Misemer (916) 654-4552****NOVEL COMPOSITE MEMBRANES FOR FUEL CELLS****EISG Grant Number:** 99-19**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Sossina Haile (626) 395-2958**Organization:** California Institute of Technology**Grant Amount:** \$74, 942**Grant Term:** 18 Months

Project Description: The purpose of this project is to research the feasibility of fabricating an anhydrous solid acid electrolyte membrane for fuel cell applications. Among the various electrolytes known for fuel cell applications, solid polymer electrolytes are particularly attractive because they permit fuel cell operation at temperatures close to ambient. Despite progress towards the commercialization of such fuel cells, market entry has not yet been realized. Key engineering challenges remain because (1) the polymer must be maintained in a hydrated state during fuel cell operation; (2) the polymer may not be exposed to temperatures exceeding ~ 100C; and (3) the polymer is permeable to fluids such as methanol. The need for hydration implies costly water recirculation hardware; the need for temperature control implies that reaction kinetics (and thereby efficiencies) cannot be improved by operation at slightly elevated temperatures, and the permeability to methanol precludes the development of direct methanol fuel cells (DMFCs) based on polymer electrolytes. Success in developing alternate, anhydrous proton conducting materials could have a tremendous impact on fuel cell technology. By eliminating the hydrous component, it is anticipated that water recirculation hardware will not be necessary and thermal management issues will be relieved (greatly simplifying the overall fuel cell system). Also, slightly elevated temperature operation will be possible (enhancing catalyst performance, increasing efficiency, and further simplifying the overall fuel cell system by improving CO tolerance). Methanol transport across the electrolyte will be negligible (enabling the development of high efficiency DMFCs.). Interest in these membranes has already been expressed by a number of industrial entities including General Motors, EPRI, Arthur D. Little, Allied Signal and Hughes Research Laboratories.

Proposed Outcomes:

- Prototype polymer/solid acid composite membrane.
- Prototype subscale membrane electrode assembly (single cells 5 cm²).
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Extend the capability of polymer electrolyte membrane (PEM) fuel cells to operate as direct methanol fuel cells, which eliminates the need for costly methanol reformers.
- Eliminate the need for costly internal water hydration system that is needed for the traditional polymer membranes thus greatly simplifying the overall fuel cell system, which reduces cost.
- Enable PEM fuel cells to operate at higher more efficient temperatures.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 20% complete overall
- Synthesis of first generation membranes 100% complete.
- Preparation, characterization and evaluation of a broad range of polymer/solid acid composite membranes 15% complete.
- Fabrication and characterization of electrodes and membrane-electrode assemblies using first generation membranes 15% complete.
- Fabrication and characterization of electrodes and membrane-electrode assemblies utilizing optimized composite membrane 0% complete.
- Demonstration of a high performance single cell fuel cell utilizing a solid acid based membrane 0% complete.

DEVELOPMENT OF A UNIQUE GAS GENERATOR FOR A NON-POLLUTING POWER PLANT**EISG Grant Number:** 99-20**PIER Area:** Energy Related Environmental Research**Principal Investigator:** Roger Anderson (916) 635-1606**Organization:** Clean Energy Systems (CES)**Grant Amount:** \$74,871**Grant Term:** 18 Months

Project Description: The purpose of this project is to research the feasibility of fabricating a combustor for a gas turbine that eliminates the production of NO_x , SO_x , CO , VOCs and particulates. This project will conduct applied research to develop and demonstrate a new gas generator concept. The gas generator combusts hydrocarbon (methane) fuel with pure oxygen to produce a turbine drive gas. Although supporting analyses have been completed, unique aspects of this device need to be physically demonstrated. Testing a sub-scale, single element unit will demonstrate: 1) that the premix injector element design produces uniform and complete mixing of the fluids before injection; 2) that reliable ignition and stable combustion of the injected fluids occurs at several temperatures and pressures; and 3) that the resultant gas generated has a defined composition and energy.

The CES concept enables the construction of extremely compact (high power density), high efficiency gas generators that can produce a high energy, environmentally clean, two-species gas (H_2O , 90%v and CO_2 , 100%v) for driving advanced turbo-generators. The device can operate on any clean, light hydrocarbon fuel and oxygen. This device is an enabling subsystem in the design of non-polluting, economical electrical power generating plants. CES is corresponding with six international power system manufacturing companies and they are evaluating the potential of their turbine technologies to take advantage of this gas generator's capabilities. The Lawrence Livermore National Laboratory and several industrial firms have agreed to team on a CES proposal to DOE to build a facility to demonstrate both non-polluting power generation and economical sequestration of CO_2 .

Proposed Outcomes:

- A subscale combustor will be fabricated and tested.
- Results of performance tests to include operation of the premix injector, ignition system and combustion stability.
- Analysis of emissions in drive gas produced during prototype testing.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Provide gas turbine electrical generation capability with zero pollution emissions.
- System would allow inexpensive capture of CO_2 since the exhaust would be comprised of 90% water and 10% CO_2 if full combustion of the O_2 and methane is achieved.

Project Status as of 11/15/00:

- On schedule

- Within budget
- 45% complete overall
- Test bench design 10% complete.
- Test bench fabrication/assembly 26% complete.
- Test bench setup and checkout 15% complete.
- Gas generator testing 0% complete.

INTEGRAL CATALYTIC COMBUSTION/FUEL REFORMING FOR GAS TURBINE CYCLES

EISG Grant Number: 99-21

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Gregory Jackson (310) 405-2368

Organization: University of Maryland

Grant Amount: \$74,992

Grant Term: 16 Months

Project Description: The purpose of this project is to research the feasibility of a novel gas turbine combustor that incorporates catalytic combustion with steam reforming of H_2 that results in a stable ultra-low NO_x combustion system for high temperature gas turbines. To extend the operability/flexibility of catalytic combustors, the University of Maryland (UMCP) in collaboration with UC-Berkeley (UCB) is proposing to investigate a novel reactor concept incorporating catalytic combustion with steam reforming to provide a stable ultra-low NO_x combustion system for high firing temperature gas turbine cycles. A subscale reactor will be fabricated and tested. The reactor, which will consist of alternating catalytic combustion and reforming flow paths in a stacked configuration, will provide a unique means of avoiding overheating of the catalytic combustor. Furthermore, the reactor will also produce a secondary stream of H_2 that may be used for flame stabilization in the combustor or may be sent to a fuel cell in a future combined power plant. Also, the implementation of new high-temperature hexaluminate catalysts and supports will enhance the long-term durability of the reactor and the ability of the reactor to work in higher firing temperature gas turbines. Thus, the innovative reactor concept will provide improved operability and performance of catalytic combustors through the following:

- 1) reduced susceptibility to overheating to allow lower quality premixing and potentially higher equivalence ratios in catalytic combustors;
- 2) potential for improved downstream flame stabilization via H_2 addition; and
- 3) increased flexibility with fuel content while maintaining ultra-low NO_x emissions.

Proposed Outcomes:

- Subscale prototype reactor.

- Analysis of reactor effectiveness under high-pressure/high temperature conditions.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce gas turbine NO_x emissions to below 5 ppm.
- Improve the thermal efficiency of gas turbines by allowing the catalytic combustor to operate at higher temperatures.
- Efficient production of H₂ that could be used for downstream flame stabilization or sent to a fuel cell for additional electrical generation.

Project Status as of 11/15/00:

- Project is approximately 2 months behind schedule
- On budget
- Task 1: Catalyst Support Screening 10% complete
- Task 2: Testing in Flat Plate Reactor 25% complete
- Task 3: Sub-Scale Reactor Design 0% complete
- Task 4: Building of Sub-Scale Reactor 0% complete
- Task 5: Testing of Sub-Scale Reactor 0% complete
- Task 6: Advanced Cycle Analysis 0% complete
- Task 7: Final Report 0% complete

PLUG-IN PHOTOVOLTAIC RECEIVER FOR CONCENTRATOR APPLICATIONS

EISG Grant Number: 99-22

PIER Area: Renewable Energy Technologies

Principal Investigator: Pierre Verlinden (408) 991-0910

Organization: SunPower Corporation

Grant Amount: \$74,977

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of fabricating a standardized plug-in photovoltaic (PV) receiver for fresnel-lens concentrator systems. High-concentration photovoltaic systems hold the potential to dramatically reduce the cost of PV electricity. By concentrating sunlight with inexpensive plastic lenses, the required area of costly solar cells can be dramatically reduced. In addition, high-concentration PV systems are more efficient - compared to conventional flat-plate silicon photovoltaic panels, they can generate about 40% to 60% more energy per unit area on an annual basis.

SunPower Corporation will develop a standardized, highly reliable, plug-in photovoltaic receiver for high-concentration Fresnel-lens systems. The plug-in PV receiver would be factory assembled and would include the following components in a single package: a PV cell, a substrate, a secondary optical element, a bypass diode, a heat spreader and heat sink, and exterior electrical and mechanical connections. Up to four prototype receiver units

will be built and tested. The yearly energy output per unit area of this PV concentrator system is expected to be much greater than a conventional flat-plate silicon module, significantly reducing balance of system (BOS) costs. For moderate volume production, the installed cost of this system will be about \$3000/kW, or about half of the cost of today's flat-plate PV systems.

Proposed Outcomes:

- Prototype plug-in PV receiver modules.
- Specifications for plug-in PV receiver module.
- Process steps for device fabrication.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduces the installed cost of fully integrated PV concentrator systems to about \$3,000/kW which is less than half the cost of current flat-plate PV systems.
- Increases the performance and reliability of concentrator systems by integrating into a single module, under factory controlled conditions, the PV cell, substrate, secondary optical element, bypass diode, heat spreader, heat sink and electrical and mechanical connections.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 65% complete overall

Design and modeling

- Electrical connection design 60% complete
- Mechanical connection design 80% complete
- Heat spreader and sink design 40% complete
- Substrate design 70% complete
- Packaging design 100% complete

Optical design

- Secondary optical element design and simulation 0% complete
- Uniformity analysis 0% complete

Thermal modeling

- Heat spreader design and simulation 50% complete
- Heat sink design and simulation 50% complete

Component selection and procurement

- Secondary optical element procurement 0% complete
- Substrate procurement 40% complete
- Bypass diode procurement 100% complete
- Electrical terminals procurement 40% complete
- Heat spreader and sink procurement 40 % complete
- Epoxy, adhesive, RTV silicone selection and procurement 50% complete

Process development

- Soldering technique development 30% complete
- Substrate to heat sink bonding technique development 50% complete

- Packaging design and development 0% complete
 - X-ray and/or ultrasonic characterization 10% complete
- Prototype fabrication 60% complete. Design selection and sample fabrication for reliability testing
- Mock-up module fabrication 0% complete
 - Design selection 0% complete
- Test development
- Flash tester adaptation 0% complete
 - Test procedure definition 30% complete
- Reliability testing
- Electrical isolation (dry Hipot) test 0% complete
 - Wet insulation-resistance test 0% complete
 - Thermal-cycle test 0% complete
 - Humidity-freeze cycle test 0% complete
 - Damp-heat test 0% complete
 - Intrusive bypass-diode thermal test 0% complete

REDUCED COST POWER ELECTRONIC CONVERTER FOR GENERATOR APPLICATIONS

EISG Grant Number: 99-23

PIER Area: Industrial/Agriculture/Water End-Use Efficiency

Principal Investigator: Herbert Hess (208) 885 4341

Organization: University of Idaho

Grant Amount: \$74,977

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of developing a more efficient and lower cost power electronic converter for use in variable speed electrical generation applications such as wind and water turbines or gas microturbines. A prototype converter will be fabricated and tested. The following three innovative, concurrent changes from the conventional method of generating with any variable speed turbine-generator system, like a wind-turbine generator, are proposed:

- 1) reduce the number of power switching devices by half;
- 2) develop a new modulation algorithm that takes advantage of common, but usually neglected filtering properties of the induction machine; and
- 3) configure a simple filter topology to capture the energy produced by the system.

The modified system has the following advantages over the conventional means of variable speed wind turbine-induction motor systems:

- 1) about half the capital cost of the power electronic converter,
- 2) retains the advantages of variable speed operation without modification to the generator itself,
- 3) energy savings come from reduced line losses and improved ability to operate the load nearer its optimum power output and efficiency,

- 4) improved system performance, particularly in the case of generating behind long radial lines, with a controllable source of both real and reactive power having very low harmonic content to enhance clean, stable operation, usable as is for variable speed conversion capability for any turbine generator, such as hydro, gas microturbines, etc.

Proposed Outcomes:

- Prototype power converter rated for 15 horsepower.
- Control algorithm for the dc bus.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce by 50% the capital cost of power electronic converters for variable speed applications.
- Enables turbines to operate at their optimum power output and efficiency.
- Saves energy by reducing line losses.
- Eliminates need to modify the generator for variable speed operation.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 45% complete overall
- Acquire hardware and software 100% complete.
- Perform simulation of 15 horsepower converter 60% complete.
- Build converters at 15 horsepower ratings 30% complete.
- Design and simulate a more sophisticated modulation method 40% complete.
- Interface to active load, verify by simulation and then experiment 0% complete.
- Develop startup procedures under active load 0% complete.
- Control the load factor, verify by simulation and experiment 0% complete.
- Interface to bus capacitor without an independently regulated rectifier 0% complete.
- Establish and refine dynamic performance 0% complete.

ATTIC AND CRAWL SPACE VENTILATION AIR HEAT EXCHANGER

EISG Grant Number: 99-24

PIER Area: Building End-Use Efficiency

Principal Investigator: G. Z. Brown (541) 346-5647

Organization: University of Oregon

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of developing a low-cost, air-to-air heat exchanger capable of 50% or greater efficiency for

use in residential and small commercial buildings. Utilizing a heat exchanger to temper the air before conditioning it will result in reduced building loads leading to down sizing of the HVAC equipment. It will also reduce energy consumption and electrical demand. The primary problem of current heat exchangers is how to reduce their cost so energy savings can pay back the initial cost of the heat exchanger in a short period of time. One solution to this problem is to exploit underused areas in residential and small commercial buildings—the crawl space or attic—to increase heat exchanger surface area and to use thin film tubes to reduce cost. Existing heat exchangers concentrate on reducing overall size while maintaining efficiency. Competitive heat exchangers include finned-tube, plate, heat pipe, and enthalpy, which are more expensive.

Proposed Outcomes:

- Two or more full-scale prototype air-to-air-heat exchanges.
- Hardware connection designs for conventional HVAC equipment.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Potential energy savings of 825 GWh/yr in California assuming only 10% and 1% market penetration in the residential and commercial building sector respectively.
- Reduce the installed cost of air-to-air heat exchangers by up to 90%.
- Improve the indoor air quality in modern airtight residential housing by providing a cost effective device for conditioning outside ventilation air

Project Status as of 11/15/00:

- Slightly behind schedule. Currently plans on finishing on schedule
- Within budget
- 32% complete overall
- Analyze and select materials 100% complete
- Design, build and test prototype heat exchangers 60% complete
- Refine computer simulation of the heat exchanger 0% complete
- Evaluate pressure drop 15% complete
- Develop the connections to HVAC equipment and to attic and crawl spaces 0% complete
- Develop heat exchanger detailed cost estimate 3% complete
- Determine operating conditions under which condensation occurs an eliminate or integrate condensation 92% complete
- Final proof of concept heat exchanger design 0% complete

REDUCING COST AND ENVIRONMENTAL IMPACT OF GEOTHERMAL POWER THROUGH MODELING OF CHEMICAL PROCESSES IN THE RESERVOIR

EISG Grant Number: 99-25

PIER Area: Renewable Energy Technologies

Principal Investigator: Subir Sanyal (510) 527-8164

Organization: GeothermEx, Inc.

Grant Amount: \$71,390

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of incorporating the recently developed TOUGHREACT code for chemical interactions into the existing TOUGH2 simulation model used for geothermal operations. Geothermal power in California today cannot compete with power from gas-fired plants because of geothermal's higher operations and maintenance ("O&M") cost. Geothermal energy's high O&M cost is due in part to the chemical problems related to geothermal fluids: deposition of chemical scales, corrosion, non-condensable gases, etc. The O&M cost of geothermal electricity could be lowered if these processes could be quantitatively modeled on the computer so that optimized mitigation steps can be taken. Such modeling will also allow enhanced reservoir management and reduction of environmental impact through minimizing gas emissions by injection optimization, and allow estimation of mineral recovery from geothermal brines. Reduction of O&M cost, enhancement of reservoir management and mineral recovery are all identified as elements of "focus" in the CEC's "Geothermal RD&D Needs and Approaches." The reduction in O&M cost and enhanced reservoir management could save on the order of 0.25 cents/kWh for most projects.

GeothermEx, Inc. proposes to work in collaboration with LBNL to apply TOUGH2 and TOUGHREACT software to solve a set of practical chemical problems encountered in several typical geothermal fields in California. These problems, drawn from published industry experience, would include:

1. Recovery of valuable minerals (such as zinc, silver and manganese) from geothermal brines;
2. Scale deposition around wells;
3. Effects of injecting acidic brine originating from various fluid handling processes;
4. Minimizing gas production through optimized water injection; and
5. Modeling of chemically reactive tracer tests to enhance reservoir management.

Proposed Outcomes:

- Produce a comprehensive geothermal model that integrates TOUGHREACT code with the TOUGH2 model.
- Feasibility assessment based on model's ability to perform under real-world conditions.

Anticipated Benefits:

- Reduce the cost of electricity generated by geothermal operations by .25 cents/kWh.
- Optimize mineral extraction strategies for California's high-salinity geothermal reservoirs.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 65% complete overall
- Install and configure TOUGHREACT on computer system 100% complete.
- Install, configure and test the TOUGHREACT code 100% complete.
- Prototypical test problem 1 (Minerals Recovery) 100% complete
- Prototypical test problem 2 (Silica Scale Deposition) 100% complete.
- Prototypical test problem 3 (Low-pH fluid injection) 100% complete.
- Prototypical test problem 4 (Long Term Gas Production Trends) 0% complete.
- Prototypical test problem 5 (Chemically Reactive Tracers) 0% complete.

CATALYTIC STABILIZER FOR INDUSTRIAL GAS TURBINES**EISG Grant Number:** 99-26**PIER Area:** Energy Related Environmental Research**Principal Investigator:** Shah Etemad (203) 787-8626**Organization:** Precision Combustion, Inc.**Grant Amount:** \$75,000**Grant Term:** 10 Months

Project Description: The purpose of this project is to research the feasibility of developing an ultra-low NO_x catalytic pilot burner for advanced industrial dry low-NO_x (DLN) gas turbines. This project will test the feasibility of a novel Precision Combustion, Inc. (PCI) concept for an ultra-low NO_x catalytic stabilizer to replace existing high NO_x pilot burners now used for start-up, turndown and base-load combustion stabilization in advanced and current industrial dry low-NO_x gas turbine machines. The project targets gas turbine power generation problems of pollutant emissions and the capital, efficiency, and operating costs incurred in minimizing generation of those pollutants.

Potential benefits include substantial reduction in NO_x emissions (to the low and middle single digit range), improved combustion stability, low combustion acoustics, improved component life, and avoiding aftertreatment costs and inefficiencies. The concept is suitable for both new engines and retrofits.

Proposed Outcomes:

- Full scale prototype of the low NO_x catalytic pilot burner.
- Feasibility assessment based on prototype performance testing in Taurus 60 combustor test rig.

Anticipated Benefits:

- Reduce NO_x emissions from dry low NO_x gas turbines from 25 ppm to below 9 ppm and reduce CO emissions to less than 5 ppm.
- Provide cost effective alternative to expensive after treatment NO_x reduction technologies.
- Designed for retrofit market and new turbine construction which increases its potential impact on California emissions.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 75% complete overall
- Establish stabilizer test conditions and physical envelope 100% complete.
- Design of embodiments of the catalytic stabilizer 55% completed.
- Perform CFD studies of the catalytic stabilizer designs 10% complete.
- Fabrication and assembly of the stabilizer and rig 10% complete.
- Atmospheric testing of the stabilizer at PCI 0% complete.
- Analyze results 0% complete.
- Full-scale high pressure combustor testing 0% complete.

VENTILATION COOLING CONTROLLER STRATEGIES**EISG Grant Number:** 99-28**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Murray Milne (310) 454-7328**Organization:** UCLA**Grant Amount:** \$74,895**Grant Term:** 15 Months

Project Description: The purpose of this project is to research the feasibility of developing an intelligent, natural-ventilation cooling controller that could determine and implement the most efficient strategy for pulling in outside air to reduce air conditioning costs in residential homes that will minimize air conditioning costs for homeowners. The greatest potential source of cooling energy in most

California climates is when cool outdoor air is available to flush overheated buildings. In most California climate zones night-time temperatures are usually quite comfortable. The controller's task is to know how much night-time air should be brought in to cool down the building's interior mass so that it can 'coast' comfortably through the next day, and not overcool so that heating is needed the following morning. This controller should also know if it is using more fan energy than it is recovering in cooling, or if wind-driven natural ventilation is available. Our studies have shown that the need for air conditioning can often be completely eliminated in many climates if the building is carefully designed and if a smart controller can be developed to harvest this resource.

Proposed Outcomes:

- Prototype ventilation cooling controller with control logic designed for the 16 climate zones in California.
- Feasibility assessment based on prototype performance testing performed in large-scale test cells.

Anticipated Benefits:

- Eliminate or reduce the need for air conditioning in California climate zones that have cool nighttime temperatures.

- Achieve minimum energy savings of 100,000 MWhr per year in California if it eliminated the need for one air conditioner per 1000.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 55% complete overall
- Design mockup test cells 100% complete
- Develop controller logic 100%
- Build fan controller 100% complete
- Design mockup test cells 100% complete
- Build mockup test cells 100% complete
- Conduct test cell experiments 75%
- Program a new Performance Model for Solar-5v 12% complete
- Validate the New solar-5v model with test cell data 0% complete
- Test with other TMY2 climate stations 0% complete
- Beta release of Solar-5v 0% complete

SOLICITATION 99-04 AWARDS

Proposals Received: 49

Passed Screening: 28

SDSU Program Administrator:

Commission Program Manager:

Approved: July 12, 2000

Grants Approved: 10 (\$741,769)

Grants Funded: 10 (\$741,769)

Hal Clark (619) 594-1158

Philip Misemer (916) 654-4552

DIRECT OPERATION OF SOLID OXIDE FUEL CELLS (SOFCs) ON NATURAL GAS

EISG Grant Number: 99-30

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Scott A. Barnett (847) 491-2447

Organization: Northwestern University

Grant Amount: \$74,958

Grant Term: 15 Months

Project Description: The purpose of this project is to research the feasibility of operating solid oxide fuel cells directly on natural gas. The key problems are to verify that the hydrocarbons can be electrochemically oxidized while avoiding carbon deposition at the fuel cell anode. For this, it will be necessary to explore alternate SOFC anode compositions. Anode performance will be characterized by chemical detection of carbon on the anodes, impedance spectroscopy, and fuel cell current-voltage measurements.

This project will show the feasibility of natural-gas-fueled SOFCs and identify new anode materials.

Proposed Outcomes:

- New anode materials capable of oxidizing hydrocarbons without carbon deposition and capable of preventing the sulfur in natural gas from poisoning the fuel cell.
- Prototype single-cell solid oxide fuel cells fabricated with the new anode materials.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce the cost and complexity of fuel cells by eliminating the need for a natural gas fuel reformer.
- Accelerate the commercialization of low cost residential fuel cells in California where low cost natural gas is already widely distributed.
- Reduction in CO₂ by facilitating the use of natural gas in fuel cells that operate at higher efficiencies than central power plants.

Project Status as of 11/15/00:

- Project projected to start on 8/15/00.
- First progress report not due until 12/15/00

NON-VACUUM THIN-FILM PHOTOVOLTAICS (PV) PROCESSES**EISG Grant Number:** 99-31**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Chris Eberspacher (805) 987-7258**Organization:** Unisun**Grant Amount:** \$75,000**Grant Term:** 7 Months

Project Description: The purpose of this project is to research the feasibility of a low cost alternative to the capital intensive vacuum techniques used to deposit thin coatings of photoactive materials in the manufacture of thin film PV. The proposed process involves depositing thin layers of particulate precursor materials and sintering the layers into high-quality PV films. One of the most promising strategies for lowering the cost of photovoltaics is the use of thin-film technologies in which thin coatings of photoactive materials are deposited on inexpensive substrates like window glass. However, the vacuum techniques typically used to deposit PV thin films are complex and capital intensive. This project will explore a simple, low-cost alternative based on non-vacuum processes.

The basic concept is to prepare fine powders of precursor materials, deposit thin layers of particulate precursor materials using simple non-vacuum techniques, and convert the layers into high-quality PV films by reactive sintering techniques. Particles simplify composition control for multi-component materials such as $\text{CuIn}_{1-x}\text{Ga}_x\text{Se}_2$ (CIGS). Layers of particles can be deposited on large-area substrates with simple non-vacuum techniques such as printing, spraying or spin-coating. Reactive sintering techniques facilitate film densification at low temperatures. Non-vacuum, particles-based processes minimize capital equipment costs, reduce manufacturing costs and increase return on investment.

Proposed Outcomes:

- Material deposition equipment that meets performance specifications.
- Application technique that yields +/- 10% thickness uniformity, > 40% packing density, and > 85% materials use efficiency
- Prototypes of thin film PV capable of 12% efficiency as single .5 cm² cells and 8% efficiency as 5 cm² integrated modules.

- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce projected manufacturing cost by 50% relative to vacuum-based thin-film PV technologies while maintaining efficiencies of 8% in modules.
- Accelerate the commercialization and market penetration of thin-film CIGS PV products.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 40% complete overall
- Procure High-MUE equipment
 - a. Gas-assisted ultrasonic 100% complete
 - b. Electrostatic 50% complete
- Test high-MUE Spraying
 - a. Morphology +/- 10%, 25% complete
 - b. MUE > 85%, 35% complete
 - c. Packing > 40%, 10% complete
- PV device fabrication
 - a. 12% cell efficiency 10% complete
 - b. 8% module efficiency 0% complete

THE USE OF SOLID OXIDE MEMBRANES IN POWER GENERATION APPLICATIONS**EISG Grant Number:** 99-32**PIER Area:** Environmentally Preferred Advance Generation**Principal Investigators:** Fokion Egolfopoulos

(213) 740-0480 and Theodore Tsotsis (213) 740-2069

Organization: University of Southern California**Grant Amount:** \$75,000**Grant Term:** 18 Months

Project Description: The purpose of this project is to evaluate the technical feasibility of using the waste heat in the exhaust stacks of power generating equipment to decompose CO₂ through the use of solid oxide membranes and to then mix the decomposed elements (CO and O₂) into the fuel stream to augment combustion thereby increasing thermal efficiency. The key objective of the proposed work is to evaluate technical feasibility, environmental implications, and long-term economic viability of a novel technology that improves electric power generation efficiency while simultaneously providing an avenue for CO₂ sequestration. The technology combines direct thermal CO₂ decomposition with an advanced power generation concept involving waste heat utilization and integration by chemical recuperation, otherwise known as the CRGT cycle. More specifically, a high-temperature, asymmetric, solid-oxide membrane reactor technology will

be developed that will allow for the direct thermal CO₂ decomposition into CO and O₂, while simultaneously utilizing waste heat in the context of power generation. The feasibility study will first focus on the choice and testing of the appropriate membrane material. Subsequently, the combustion characteristics of the resulting fuel blends of CH₄/CO/CO₂/O₂/N₂, will be systematically quantified since their combustion characteristics have not been studied systematically in the past.

Proposed Outcomes:

- Membrane technology that will be appropriate for the direct thermal decomposition of CO₂.
- Quantification of the combustion characteristics of fuel blends of CH₄/CO/CO₂/O₂/N₂
- Feasibility assessment based on the prototype membrane and combustion testing.

Anticipated Benefits:

- Reduce the cost of power generation in systems that utilize combustion by using the waste heat to improve thermal efficiency or by selling the decomposed elements (CO and O₂) to partially offset the cost of generation.
- Reduce CO₂ emissions and would enable CO₂ sequestration if desired.

Project Status as of 11/15/00:

- Project started 8/15/00.
- First progress report not due until 12/15/00.

TWO-PHASE FLOW TURBINE FOR CO-GENERATION, GEOTHERMAL, SOLAR AND OTHER APPLICATIONS

EISG Grant Number: 99-33

PIER Area: Renewable Energy Technologies

Principal Investigator: Gracio Fabis (818) 952-0217

Organization: FAS Engineering, Inc.

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of a new design for a two-phase flow turbine capable of operating at higher thermal efficiencies in geothermal power generation applications. Use of two-phase turbines (hot water plus steam) in small size cogeneration has substantial advantage over gas turbine cogeneration. The reason is that in the Brayton cycle case the compressor uses up over 70% of mechanical power delivered by the gas turbine. When steam is used, the compression power is only a few percentage points of the two-phase turbine power output. Various market applications are already mentioned. Early implementation could be to retrofit topping part of the

existing, both, flash and binary type geothermal power plants. Small size early applications for waste heat utilization and cogeneration involving water and spaced heating are attractive as well. Efficiencies and economics obtainable using this device and its thermal cycles (topping flash retrofits, cogeneration, trilateral, heat pumps and others) are favorable.

Proposed Outcomes:

- 30 kW subscale prototype turbine.
- Measure efficiency values.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Increases turbine thermal efficiency by 20% - 40% in binary and flash type geothermal applications.
- Potential to increase efficiency in solar and thermal waste heat applications.
- Design is scalable to both small and large turbine applications.

Project Status as of 11/15/00.

- On schedule
- Within budget
- 30% complete overall
- Submitted drawings for fabrication 100% complete
- Prototype components fabricated 100% complete
- Prototype turbine assembled 80% complete
- Test rig 40% complete
- Prototype tests 0% complete

COST EFFECTIVE, LOW DISTORTION, ADJUSTABLE SPEED DRIVES

EISG Grant Number: 99-34

PIER Area: Industrial/Agriculture/Water-End-Use Efficiency

Project Manager: Arthur Iversen (408) 354-7972

Principal Investigator: George Gabor (925) 284-9529

Organization: Spinel LLC.

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of a new, low cost, pulse width modulated (PWM) inverter design capable of producing pure waveforms for controlling adjustable speed drive (ASD) motors. The focus of the project is to establish the feasibility of building adjustable speed drives (ASDs) that do not produce the distorted waveforms that cause premature motor failures such as those generated by the ASDs now in use. Electric motors are designed to run on sinusoidal utility power (60 Hz). An advanced ASD,

employing high frequency switching, >60kHz allows the synthesis of essentially pure sine waves, cleaner than those received from the Utility, that provides normal motor life. Agricultural uses of ASD motors include programmed pump irrigation, and uses in produce conveyers and processing systems. ASD pumps are used to control water flow in water transport and sewage treatment plants.

Proposed Outcomes:

- A prototype motor controller will be fabricated and tested on a three-phase 5 HP motor.
- Prototype three-phase inverter capable of producing pure variable frequency sine waves with current harmonics less than 5% and efficiency greater than 92% regardless of cable length.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Low cost solution to eliminating premature ASD motor failures due to leading edge PWM pulse spikes which cause premature insulation failure.
- Eliminate or minimize costly harmonic filters and associated engineering analysis that is currently required for harmonic sensitive ASD installations.
- Significantly increase ASD market penetration which is currently only 9% due to lack of confidence in the technology

Project Status as of 11/15/00:

- On schedule
- Within budget
- Overall 45% complete
- 10 kW high frequency, low harmonic AC-DC converter
 - Design 95% complete
 - Construction & debugging 20% complete
 - Demonstrate 100% complete
- 10kW single phase (one leg of three phase)
 - Design 0% complete
 - Construction & debugging 0% complete
 - Interface with converter 0% complete
 - Test and operation 0% complete
- 10kW three phase PWM variable frequency inverter (DC-AC)
 - Design 0% complete
 - Construction & debugging 0% complete
 - Interface with converter 0% complete
 - ASD operation of a 5hp-three phase blower 0% complete

COMPOSITE ARCHITECTURES FOR SUB-600°C SOLID OXIDE FUEL CELLS

EISG Grant Number: 99-35

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Lutgard De Jonghe
(510) 486-4881

Organization: UC Berkeley

Grant Amount: \$70,811

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of producing a composite solid oxide fuel cell (SOFC) membrane assembly that optimally combines reforming and catalytic functions with high cathode and anode electronic conductivity. The methods used involve colloidal processing techniques, offering potentially low fabrication costs. The ceramic SOFC membranes have a novel composite architecture that optimally combines the reforming and catalytic functions with high electronic conductivity, through the choice of materials and microstructure. The methods by which the composite membranes are produced involve colloidal processing and common ceramic processing techniques, thereby avoiding costly production steps, and therefore significantly enhance the feasibility of the concept.

Decreasing the temperature of operation of an SOFC, down from the current 1000°C operation, can significantly alleviate materials compatibility and durability problems in the SOFC stack, reducing the cost of this technology while maintaining its advantages. Increasing the materials and system reliability and lowering cost of SOFCs are essential factors in enabling broad commercial introduction of the energy efficient SOFC technology, both at the residential and small to intermediate industrial scale.

Proposed Outcomes:

- Prototype fuel cell membrane with an overall membrane resistance of less than 1 ohm/cm² that can operate efficiently at or near 600°C.
- Fabrication process for low-cost fuel cell membranes.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce the manufacturing cost of solid oxide fuel cells as a result of reducing the operating temperature that reduces the need for expensive materials.
- Increase the reliability of solid oxide fuel cells by reducing material compatibility problems that are caused by high operating temperatures.

Project Status as of 11/15/00:

- Project started on 8/15/00.
- First progress report not due until 12/15/00

ENERGY PRODUCTION FROM BULK WASTEWATER USING OPTIMIZED SUPERSYNTHETIC BACTERIA

EISG Grant Number: 99-36

PIER Area: Renewable Energy Technologies

Principal Investigator: Eric McFarland (805) 893-4343

Organization: UC Santa Barbara

Grant Amount: \$75,000

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of producing wastewater microorganisms capable of efficient biosynthesis of hydrogen gas. The most promising microorganisms will be cultured and tested in a prototype sub-scale anaerobic digester. Anaerobic digesters have no free oxygen. Anaerobes get oxygen by the decomposition of compounds containing it. The technical objective of this project is to develop a means for the efficient, economic, biosynthesis of hydrogen gas (H₂) in wastewater anaerobic digesters for use as an environmentally clean fuel. Though scheduled first for automobile use, future electricity generation systems will increasingly use hydrogen if a cost effective source of hydrogen gas becomes available. While hydrogen can be produced by reformation, decomposition, or electrolysis, these methods are relatively energy intensive or utilize non-renewable resources. An attractive alternative for H₂ production has been biosynthesis; however, to date the practical realization of bulk hydrogen synthesis from living organisms has not been achieved.

Proposed Outcomes:

- Combinatorial methodology for screening microorganisms capable of optimal H₂ production.
- Prototype bench top digester/bioreactor.
- Feasibility analysis based on performance testing of selected microorganisms in prototype bioreactor.

Anticipated Benefits:

- Demonstrate the effectiveness of combinatorial methodology in the screening of numerous genetically diverse mutant microorganisms for optimal H₂ production.
- Increase H₂ production from wastewater anaerobic digesters to a level that makes power generation commercially viable.

Project Status as of 11/15/00:

- Project started on 8/15/00.
- First progress report not due until 12/15/00

DEVELOPMENT OF A BOREHOLE SEISMIC RECEIVER ARRAY FOR GEOTHERMAL WELLS

EISG Grant Number: 99-37

PIER Area: Renewable Energy Technologies

Principal Investigator: Bjorn Paulsson (562) 694-9598

Organization: Paulsson Geophysical Services, Inc.

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of developing a borehole seismic receiver array for geothermal wells capable of operating in a temperature range of 200°-250°C. Existing short and low temperature arrays severely limit the use of borehole seismology in geothermal energy exploration. This project will address this shortcoming by developing a much larger seismic receiver array that can operate at much higher temperatures. Large borehole seismic receiver array technology will make it possible to routinely map high permeability zones and monitor production in fractured geothermal reservoirs with a resolution in the range of 3 to 6 ft (1 - 2 m) using 3D VSP, passive seismic monitoring and cross well seismic techniques. Three component arrays allow recording of both P and S wave data that together provide information on the location, the size and the preferred direction of fractures and fracture zones in the reservoir. The fracture information is the key information that will help determine the directional permeability of the reservoir and how to economically produce its geothermal resources.

Proposed Outcomes:

- Cable design capable of withstanding operational temperatures of 200°–250°C.
- A prototype five-level high-temperature borehole seismic receiver array.
- Feasibility assessment based on prototype performance testing in field setting.

Anticipated Benefits:

- Ability to record P and S wave data that enable the mapping of fracture zones in high-temperature geothermal reservoirs.
- Enable more efficient management of existing geothermal reservoirs.
- Reduce the number of wells needed to develop a geothermal resource.
- Allow economic development of lower temperature and lower permeability geothermal fields.

Project Status as of 11/15/00.

- Project started on 8/15/00.
- First progress report not due until 12/15/00

ANAEROBIC PUMP

EISG Grant Number: 99-38

PIER Area: Renewable Energy Technologies

Principal Investigator: Keith Schimel (315) 425-7741

Organization: Technology Matrix Corp.

Grant Amount: \$71,000

Grant Term: 6 Months

Project Description: The purpose of this project is to research the feasibility of a new two-stage anaerobic digester design capable of converting wet biomass to methane. The Anaerobic Pump (AP) is a two stage, hybrid anaerobic process for converting wet biomass to biogas (methane, carbon dioxide and ammonia gases). The unique reactor design drives hydrolysis due to including a combination of three technical advancements; (1) gas transfer via applied low pressure, (2) automatic in-reactor substrate and bacterial thickening, and (3) plasticization via applied high pressure. Conventional Anaerobic digestion achieves limited volatile solids reduction (20-40%) because it is based on gas-liquid equilibrium. Instead, the Anaerobic Pump utilizes the gases produced by anaerobes to drive hydrolysis via innovative pressure swing design. The objective of this project is to test the Anaerobic Pump's ability to completely convert a waste sludge mixture, including the nondigestible fraction of the sludge mixture, through three steady states.

Proposed Outcomes:

- Subscale prototype system.
- Quantitative test data on prototype operation under three steady-state conditions.
- Feasibility analysis based on performance of prototype system.

Anticipated Benefits:

- Provide an efficient method of producing methane from renewable industrial and agricultural wastewater streams which could be used to produce 200-400 MW valued at \$5-\$10 million per year.
- Increase conversion of volatile solids from 40% to approximately 90% through use of the two stage anaerobic digester, which significantly reduces disposal costs and volume of the remaining material.
- Mitigate California groundwater contamination associated with land disposal methods of animal and municipal wastes.
- Reduce greenhouse gas emissions of methane into environment.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 50% complete overall
- Steady state comparison #1 100% complete
- Steady state comparison #2 100% complete
- Steady state comparison #3 0% complete

HIGH-EFFICIENCY SINGLE PHASE AIR CONDITIONER

EISG Grant Number: 99-39

PIER Area: Building End-Use Efficiency

Principal Investigator: Otto Smith (510) 525-9126

Organization: Individual

Grant Amount: \$75,000

Grant Term: 18 months

Project Description: The purpose of this project is to research the feasibility of a motor controller that enables high-efficiency, three-phase air conditioners to be operated from a single-phase power source that is typical in residential and rural locations. This project will provide a control that enables high-efficiency three-phase air conditioners to be supplied directly from single-phase residential outlets and rural electrical connections. The "enabler" has starting capacitors and motor-run capacitors in addition to the usual line contactor and starting contactor.

Proposed Outcomes:

- Prototype motor controller.
- Quantitative test data of three phase and single phase AC units operating on single phase power under controlled conditions.
- Feasibility analysis based on prototype performance.

Anticipated Benefits:

- Reduce air conditioning electrical consumption by 10%.
- Reduce voltage drop and current spike during start up.
- Improve power factor

Project Status as of 11/15/00

- Project started 8/15/00
- First progress report not due until 12/15/00

SOLICITATION 00-01 AWARDS**Proposals Received: 25****Passed Screening: 19****SDSU Program Administrator:****Commission Program Manager:****Approved: September 20, 2000****Grants Approved: 7 (\$524,751)****Grants Funded: 7 (\$524,751)****Hal Clark (619) 594-1158****Philip Misemer (916) 654-4552****CLOSED-CYCLE VALVED CELL HEAT ENGINE****EISG Grant Number:** 00-01**PIER Area:** Renewable Energy Technology**Principal Investigator:** Joseph Bland (916) 429-6252**Organization:** Individual**Grant Amount:** \$75,000**Grant Term:** 12 months

Project Description: The purpose of this project is to research the feasibility of fabricating a low cost heat engine that is capable of operating efficiently on low-temperature external heat sources. This project will construct, test and analyze a proof-of-principle prototype of a closed-cycle Valved Cell Engine (VCE). The objectives of the project are to determine if it is technically and economically feasible to fabricate the proposed engine design and to establish that the proposed design is capable of operating effectively from external heat sources in the range of 500-800° F. The VCE is targeted at low temperature heat sources because of its unique ability to deliver very high work output per pound of working fluid (about 50% greater than that of a comparable Stirling engine), The VCE can operate effectively and efficiently at these very low source temperatures. This makes it an ideal heat engine for solar, geothermal and waste heat applications. The VCE's power density also means it can tap efficiently into very small heat sources.

Proposed Outcomes:

- Prototype closed-cycle valved cell engine.
- Feasibility analysis based on prototype performance.

Anticipated Benefits:

- Low cost heat engine design capable of generating 2-3 kW from concentrated solar or other low temperature sources.
- 0% higher work output per pound of working fluid compared to a sterling engine.
- Low capital cost with 3-5 year pay back period.
- Zero emissions when operated from solar energy.

Project Status 11/15/00:

- Projected start date 11/1/00
- First progress report not due until 2/1/01.

SINGLE CRYSTAL SILICON SHEET GROWTH**EISG Grant Number:** 00-02**PIER Area:** Renewable Energy Technology**Principal Investigator:** Carl Bleil (248) 370-3406**Organization:** Energy Materials Research**Grant Amount:** \$75,000**Grant Term:** 18 months

Project Description: The purpose of this project is to research the feasibility of producing single crystal sheets of semiconductor quality silicon directly from a polycrystalline source at a minimum production rate of 35 cm/min up to maximum of 350 cm/min using an advanced Horizontal Ribbon Growth (HRG) method. The patented approach presented here and validated in the laboratory addresses the critical control features of a modified HRG process necessary to realize the continuous growth of single crystal silicon sheets. A unique concept invoking capacitive coupling of RF power to the silicon sheet seed is employed. When properly applied in a uniform thermal environment, it allows disturbances at the nucleating tip and at the exit solid-liquid phase boundary to be eliminated. The problems of maintaining a uniform thermal environment, controlling temperature gradients, and preventing polycrystalline nucleation are resolved. The process permits the stable growth of the silicon sheet to be controlled electrically, making the HRG method a practical process.

Proposed Outcomes:

- Prototype Horizontal Ribbon Growth processor.
- Production methodology.
- Technical and economic feasibility analysis of proposed methodology.

Anticipated Benefits:

- 50% reduction in the energy consumed to produce quality silicon sheet.
- 40% reduction in the material losses associated with producing single crystal sheets.
- Potential 50% capital cost reduction of electronic grade silicon sheets.

Project Status 11/15/00:

- Projected start date 10/15/00
- First progress report not due until 1/15/01.

AGF PASTEURIZATION PROCESS ASSESSMENT, ORANGE COUNTY, CA

EISG Grant Number: 00-03

PIER Area: Renewable Energy Technology

Principal Investigator: Dennis Burke (360) 923-2000

Organization: Cyclus EnviroSystems

Grant Amount: \$75,000

Grant Term: 18 months

Project Description: The purpose of this project is to research the feasibility of a pilot plant using an anoxic gas flotation pasteurization process to more efficiently convert organic materials such as agricultural waste, sewage sludge, and manure into fuel gas and Class A residual solids. The innovative process can use the heat recovered from power generation to increase the quantity of organic material converted to gas while producing disinfected nutrient rich, residual. More gas is produced; fewer residual solids must be disposed, public health is protected, while the capital and operating costs of waste treatment and power generation is reduced. The biochemical process is the anoxic gas flotation (AGF) pasteurization process that utilizes high temperature waste heat from a turbine, microturbine, or engine generator set to increase the rate and quantity of organic material converted to gas. A 40% improvement in solids converted to gas has been shown at laboratory bench scale. The AGF pasteurization process also reduces the amount of process energy required when compared to conventional or thermophilic digestion processes and the quantity of the concentrated, nutrient rich, residual product to be disposed. The disinfected residual product can be given or sold to the general public, locally, without restriction.

Proposed Outcomes:

- Pilot plant capable of processing 400 gpd of sewage sludge.
- Optimized methodology for operating processing plant.
- Feasibility analysis based on pilot plant performance.

Anticipated Benefits:

- Up to 40% increase in conversion rate of organic solids to biogas.
- Increase fuel gas production by 25%
- Reduce solids processing costs by 60%.
- Produce a disinfected Class A residual product that does not require landfill disposal.

Project Status 11/15/00:

- Projected start date 10/15/00
- First progress report not due until 1/15/01.

CARBON FOAM BASED NO_x BIOFILTER

EISG Grant Number: 00-04

PIER Area: Energy-Related Environmental Research

Principal Investigator: Daniel Chang (530) 752-2537

Organization: UC Davis

Grant Amount: \$74,989

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of using Ultramet carbon foam as a packing material in a post combustion NO_x biofilter to increase efficiency and reduce capital cost.). However, biofiltration to control NO_x is difficult because of mass transfer rate limitations. Newly engineered materials developed for other applications, e.g., Ultramet carbon foam for catalyst supports, can be tailored to meet the needs of an inexpensive, light weight, inert, biofilter packing that provides a high specific surface area (surface-to-volume) to greatly increase the mass transfer rate. We believe that the key to economical biological treatment of NO is to maximize the specific surface that can support the necessary biofilm without clogging. The objective of this work is to conduct energy-related environmental research that demonstrates the feasibility of developing a commercially viable NO_x biofilter.

Proposed Outcomes:

- Subscale prototype biofilters.
- Design parameters for system scale up.
- Feasibility analysis based on performance of prototype biofilters.

Anticipated Benefits:

- Reduce the cost of NO_x removal by at least 50% to \$0.40/lb-NO_x
- Provide cost effective means of lowering emissions from small-distributed generation units.

Project Status 11/15/00:

- Projected start date 10/1/00.
- First progress report not due until 1/1/00.

CORROSION RESISTANT COATING FOR CARBONATE FUEL CELL COMPONENTS

EISG Grant Number: 00-05

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Yuhong Huang (818) 727-9786

Organization: Chemat Technology, Inc.

Grant Amount: \$75,000

Grant Term: 18 months

Project Description: The purpose of this project is to research the feasibility of increasing the life of molten carbonate fuel cells by using a sol-gel coating of LiCoO_2 on the NiO cathode and cathode current collector to reduce corrosion. The primary objective of this proposed research is to solve one of the most serious problems in molten carbonate fuel cells: corrosion of cathode current collector and lithiated NiO cathode, which has been a major lifetime-limiting factor. In this proposed project, a sol-gel coating process will be developed to improve the performance of cathodes and cathode current collector. By carefully selecting the coating materials, the corrosion resistance can be enhanced dramatically. Consequently, the lifetime and power generation efficiency of this fuel cell can be improved simultaneously.

Proposed Outcomes:

- Material samples will be fabricated with sol-gel coating
- Methodology for applying sol-gel coating
- Feasibility analysis based on performance of material samples

Anticipated Benefits:

- Increase fuel cell life by 100%
- Increases capital cost of cathode and current collector by less than 2%

Project Status 2/1/01:

- Projected start date 10/15/00
- On 2/2/01 Chemat Technology changed the PI on this project from Gengwei Jiang to Yuhong Huang.
- First progress report not due until 2/15/01

BIOMASS BOUNDARY LAYER TURBINE POWER SYSTEM

EISG Grant Number: 00-06

PIER Area: Renewable Energy Technologies

Principal Investigator: Darren Schmidt (701) 772-5281

Organization: EnergySchmidt

Grant Amount: \$75,000

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of driving a boundary layer turbine with a low-cost biomass combustor for the purpose of generating electricity. The boundary layer turbine is the key component for creating an economical small biomass power system. The expected capital cost of the first systems would be \$600/kW. The technology proposed here is addressing the problem of integrating small biomass power systems into the distributed generation market. The solution in this proposal could potentially lead

towards the development of a small power system that would economically compete directly with diesel engines in the distributed power generation market. The proposed technology would consist of coupling a boundary layer turbine with a biomass combustion system to produce electricity and heat. The boundary layer turbine is attractive because it would allow for much higher concentrations of contaminants in the gas stream relative to current commercial turbines and reciprocating engines.

Proposed Outcomes:

- Prototype system
- Biomass combustor design compatible with boundary layer turbine
- Feasibility analysis based on prototype performance

Anticipated Benefits:

- Divert combustible biomass from landfills
- Reduce emissions from open air burning of biomass
- Reduce NO_x and CO_2 emissions to the extent that it offsets power generation from fossil fuels
- Fixed and portable biomass power generation systems that are durable and require less maintenance
- System capital cost of \$600/kW with a 6.7 year payback from a 1-MW system

Project Status 11/15/00:

- Projected start date 12/1/01
- First progress report not due until 3/1/01

IMPROVED PERFORMANCE OF ENERGY RECOVERY VENTILATORS USING ADVANCED POROUS HEAT TRANSFER MEDIA

EISG Grant Number: 00-07

PIER Area: Building End Use

Principal Investigator: Mark Tillack (858) 534-7897

Co-Principal Investigator: Rene Raffray (858) 534-9720

Organization: UC San Diego

Grant Amount: \$74,762

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of using advanced porous media to increase the heat transfer efficiency of heat recovery ventilators to 90% (current technology is 50-80% efficient). The current trend toward sealing houses to reduce air and moisture infiltration makes them more energy efficient and reduces home energy costs. Depending on the local climate, appliance use and sealing method, tighter houses can be 15% to 30% more energy efficient. However, as homes and commercial buildings become more leak tight, adequate ventilation becomes increasingly important in

order to avoid air quality problems. If a house is constructed tighter than 0.35 air changes per hour, any pollutants generated in the home can accumulate and reduce the indoor air quality to unhealthy levels. If fresh outside air is brought in through an open window to alleviate this problem, this air may be excessively hot, cold or humidity-laden and require conditioning at added expense. Energy recovery ventilators (ERVs) use air-to-air heat exchangers to retain building heat or cooling. The heart of the system is the heat exchanger, which in some cases is used also to aid in filtration and/or humidity control. Substantial improvements in heat transfer efficiency are possible using modern low-cost gas-phase heat exchanger technology. Increasing the heat transfer effectiveness to 90% would provide a factor of 2-5 decrease in energy loss.

Proposed Outcomes:

- Fabrication of porous medium samples
- Optimized heat recovery ventilator design
- Feasibility analysis based on performance of test samples

Anticipated Benefits:

- Provide a cost effective and energy efficient means of maintaining indoor air quality in structures that are built airtight
- Encourage the construction of airtight houses that are 15%-30% more energy efficient

Project Status 11/15/00:

- Projected start date 10/15/00
- First progress report not due until 1/15/01

SOLICITATION 00-02 AWARDS

Proposals Received: 40

Passed Screening: 26

SDSU Program Administrator:

Commission Program Manager:

Approved: December 20, 2000

Grants Approved: 11 (\$818,194)

Grants Funded: 11 (\$818,194)

Hal Clark (619) 594-1158

Philip Misemer (916) 654-4552

PROPOSAL TO RESEARCH ENERGY-EFFICIENT DESIGNS FOR SWIMMING POOL PUMP SYSTEMS

EISG Grant Number: 00-08

PIER Area: Building End Use

Principal Investigator: Taghi Alereza (916) 363-8383

Organization: ADM Associates, Inc.

Grant Amount: \$74,691

Grant Term: 9 months

Project Description: The purpose of this project is to research the feasibility of reducing the flow rate of the filter pumps on commercial and educational swimming pools while maintaining the required water quality. In educational and commercial facilities with swimming pools, it is often standard practice to run the pumps for the pool filtration system continuously at the design flow rate. Although engineering calculations show that it is reasonable to reduce the flow rate for a pool filtration system below the design flow rate, an important barrier to making this energy saving change is a concern about water quality and health problems. Health standards generally require that a minimum flow rate be maintained for public pools.

Many pool filter systems are as or more effective when operated with lower flow rates. However, it has been standard practice to design the filtration system for an educational or commercial facility with a swimming pool

with a single pump that runs continuously at the design flow rate. Because swimming pools in educational and commercial facilities are generally not open 24 hours a day, there is room to reduce the flow rate of the filtration system pump during those hours when the pool is not in use. The question at issue is how much the flow rate can be reduced during hours when the pool is not actually being used without compromising the water quality needed for health reasons. Various aspects of water quality will be monitored, including the following:

- Turbidity or clarity of the water;
- pH level (which needs to be maintained between 7.2 and 8.0);
- Free chlorine residuals;
- Bacteriological quality of the water; and
- Chemical quality of the water.

Proposed Outcomes:

- Optimized energy efficient strategy for operating swimming pool filter pumps.
- Feasibility analysis based on performance of modified pump operation at test sites.

Anticipated Benefits:

- Estimated energy savings of 20,000 kWh per year per pool based on a 25% deduction in flow rate for 8 hours per day.
- Potential to save 840 MWh per year in CA from approximately 40,000 candidate pools.

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

COUNTER ROTATING WIND TURBINE SYSTEM**EISG Grant Number:** 00-09**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Kari Appa (949) 458-7314**Organization:** Appa Technology Initiatives**Grant Amount:** \$74,915**Grant Term:** 12 months

Project Description: The purpose of this project is to research the feasibility of developing a more efficient wind turbine by employing a design that incorporates dual, counter-rotating rotor blades. To extract more energy from wind stream, Appa Technology Initiatives (ATI) proposes a counter rotating wind turbine system that enhances the efficiency factor to 40 to 50%. Consequently this will reduce both the energy cost (\$/kWh) and capital cost (\$/kW) by half. The benefits of the proposed innovation are: (1) a higher magnetic flux speed translating to an efficient light weight alternator at low cost and (2) zero torque load on supporting structure which results in reduced weight and capital cost. Two subscale prototypes of the counter rotating turbines will be fabricated and tested. A US patent on the counter rotating turbine system is being awarded to Appa.

Proposed Outcomes:

- Prototype wind turbine with counter rotating rotors
- Improved wind turbine alternator design
- Feasibility analysis based on performance of prototype

Anticipated Benefits:

- Increase wind turbine efficiency by 20-30%
- Achieve power generation cost of 3.5 cents/kWh
- Reduce capital cost of installation due to reduced torque load on support structure
- Retrofit existing utility scale wind turbines with downwind counter rotating turbines for enhancement of power generation.

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

INCREASING EFFICIENCY OF GEOTHERMAL ENERGY GENERATION WITH HIGH RESOLUTION SEISMIC IMAGING**EISG Grant Number:** 00-10**PIER Area:** Renewable Energy Technology**Principal Investigator:** Dimitri Bevc (650) 969-3886**Organization:** 3DGeo Development Inc.**Grant Amount:** \$75,000**Grant Term:** 9 months

Project Description: The purpose of this project is to research the feasibility of improving seismic image resolution of geothermal reservoirs by applying innovative seismic data processing techniques. The approach will be validated against a data set from an existing geothermal field. The efficiency and economy of geothermal energy generation can be greatly increased by obtaining critical reservoir information from active-source reflection seismology. The objective of this project is to improve resolution and imaging of geothermal reservoirs by applying innovative seismic data processing techniques that will directly address the key issues which traditionally plague seismic data collected in geothermal areas; namely, (1) propagation through a highly variable near surface, and (2) imaging steeply dipping complex reservoir structures. A data processing methodology that facilitates exploration in complex areas, improves geothermal reservoir characterization, and decreases the much higher costs of exploratory drilling and failed water re-injection projects will be developed and demonstrated.

Proposed Outcomes:

- Improved methodology for processing seismic data
- Feasibility analysis based on performance of proposed processing methodology

Anticipated Benefits:

- Reduce the number of wells drilled per geothermal field by 2-5 at a savings of \$1.5-\$4.0 million per well.
- Improve the imaging of geothermal fields with complex near-surface geology in which current imaging technologies do not perform well.

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

DISTRIBUTED GENERATION DRIVETRAIN FOR WINDPOWER APPLICATION**EISG Grant Number:** 00-11**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Geoff Deane (805) 899-9199**Organization:** Dehlsen Associates, LLC**Grant Amount:** \$75,000**Grant Term:** 8 months

Project Description: The purpose of this project is to research the feasibility of an innovative drivetrain design for large-scale wind turbines. As wind turbines have grown, rates of revolution, limited by tip speeds on larger rotor diameters, have decreased while power has increased, increasing the torque seen by the turbines' speed-increasing gearboxes. Because of this detrimental scaling effect, for turbines growing into the megawatt range, gearboxes comprise increasing percentages of the total capital and lifetime costs, limiting the potential for reduction of energy cost. In addition, as turbine size has grown, increasing failures of the larger gearboxes have resulted in the most substantial financial loss to the industry in recent years, posing a serious concern to the industry as a whole. Dehlsen Associates (DA) has developed and engineered a new gearbox concept, a novel approach to this high-torque, low rotational speed stumbling block. This proposal outlines a project to demonstrate a 2.5 kW prototype Distributed Generation Drivetrain (DGD) and to develop the associated controller. The prototype is designed to eventually be installed on a wind turbine, but for the scope of this work, will be tested on a dynamometer. Detailed real-time data will be acquired during the tests to quantify dynamic behavior, efficiency, load balance, and the success of the control strategy. Results of this study will lend insight to the development of a commercial-scale DGD system.

Proposed Outcomes:

- Prototype drivetrain for 2.5 kW wind turbine
- Prototype controller
- Feasibility analysis based on performance of prototype controller and drivetrain

Anticipated Benefits:

- Reduce the capital cost of installation of large wind turbines by 7%
- Reduce lifecycle maintenance costs by 30%
- Reduce the cost of power generation from 3.88 cents/kWh to 3.46 cents / kWh

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

ENERGY-EFFICIENT AIR-HANDLING CONTROLS

EISG Grant Number: 00-12

PIER Area: Building End Use

Principal Investigator: Clifford Federspiel (510) 418-3392

Organization: Federspiel Controls

Grant Amount: \$75,000

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of a more energy efficient method of controlling air-handling equipment in buildings to minimize the fan power and cooling power required to achieve the functional requirements of ventilation, pressurization and temperature control. The concept is to use extra control degrees of freedom to minimize power consumption while achieving the desired ventilation, temperature, and building pressure conditions. The extra control degrees of freedom arise because there are more control elements (dampers, fan speed controls, heating and cooling coils) than control requirements (ventilation, duct or space temperature, building pressure). A rule-based controller will be designed by deriving rules from the observation of optimal performance.

Existing methods of controlling air-handling systems consume considerably more energy than is necessary to meet the functional requirements of ventilation, pressurization, and temperature control. It is estimated that a nearly optimal control strategy could reduce fan energy consumption by 30% relative to the best current practice and by 60% relative to the typical current practice. In addition to fan power reduction, a nearly optimal strategy could reduce heating and cooling energy consumption by avoiding over-ventilation during hot or cold weather.

Proposed Outcomes:

- Optimized control logic for achieving energy efficient operation of air-handling equipment
- Feasibility analysis based on a comparison of existing and proposed control strategies using modeling and simulation

Anticipated Benefits:

- Reduce fan energy consumption by 20-40%
- Reduce heating and cooling power by 10%
- Potential energy savings of .8 quad in the U.S. and .1 quad in California

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

OMNI-DIRECTIONAL INSECT EYE CONCENTRATOR USING A HYPER-SPECTRAL PHOTOVOLTAIC CAVITY CONVERTER (PVCC)

EISG Grant Number: 00-13

PIER Area: Renewable Energy Technologies

Principal Investigator: C. Wood Hays (760) 744-2575

Organization: United Innovations, Inc.

Grant Amount: \$74,992

Grant Term: 6 months

Project Description: The purpose of this project is to research the feasibility of a high efficiency PV system that utilizes an omni-directional insect eye concentrator (OMNICON) to direct light into a cavity that is lined with single junction solar cells that are coated such that they absorb a specific portion of the light spectrum and reflect the remainder of the spectrum to the other cells in the cavity. OMNICON combines two new technologies, the omni-directional insect eye to eliminate tracking, and a light-confining cavity for high efficiency. In the cavity, the solar spectrum is split into several frequency bands, and a set of single junction solar cells with complementary band gaps efficiently converts matching photons into electricity. Splitting is caused by selective transmission and reflection of photons with Rugate filters on the cells.

Proposed Outcomes:

- Optimized system design that incorporates the concentrator, Rugate filters and single junction PV cells
- Feasibility analysis based on modeling and system design

Anticipated Benefits:

- Increase PV efficiency in converting solar energy into electricity from the current level of 8 - 16% to at least 38%.
- Reduce the installed cost of PV from \$5 - \$6/Watt to \$1.50 - \$3.00/Watt

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

RESEARCH ON MANUFACTURING QUADRUPLE-JUNCTION SOLAR CELLS

EISG Grant Number: 00-14

PIER Area: Renewable Energy Technologies

Principal Investigator: Robert Hicks (310) 825-8891

Organization: UC Los Angeles

Grant Amount: \$74,268

Grant Term: 18 months

Project Description: The purpose of this project is to research the feasibility of increasing the conversion efficiency of quadruple-junction solar cells by optimizing the chemical vapor deposition process. Quadruple-junction solar cells show great potential for achieving terrestrial conversion efficiencies above 40%. At these levels, the photovoltaic devices could be competitive for large-scale electric power generation. Quadruple-junction solar cells consist of epitaxial thin films of indium, gallium phosphide (In_{0.48}Ga_{0.52}P), gallium arsenide and indium gallium arsenic nitride (In_{0.09}Ga_{0.91}As_{0.97}NO_{0.03}) lattice-

matched to germanium substrates. These materials are produced by a sophisticated chemical process known as metalorganic chemical vapor deposition (MOCVD). The objective of this project is to identify the MOCVD process conditions crucial to the development of a robust manufacturing technology. This technology must be capable of producing defect-free films with sharp interfaces and precise composition profiles. The atomic and microscopic structures produced by MOCVD will be characterized by scanning tunneling microscopy, x-ray photoemission, spectroscopy, high-resolution x-ray diffraction, photoluminescence and current-voltage measurements. New deposition process will be developed and examined for the fabrication of quadruple-junction solar cells with light conversion efficiencies exceeding 40%.

Proposed Outcomes:

- Methodology for vapor deposition process that yields precise smooth layers with sharp interfaces between layers
- Feasibility analysis based on performance of fabricated test samples

Anticipated Benefits:

- Solar power production at a cost of \$.03-\$.04 kWh
- Achieve solar cell conversion efficiency over 40%

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

HIGHLY CONDUCTIVE, WATER INSOLUBLE & THERMALLY STABLE PROTON EXCHANGE MEMBRANE (PEM) FROM FUNCTIONALIZED POLYOXOMETALATES (POMS)

EISG Grant Number: 00-15

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Yuhong Huang (818) 727-9786

Organization: Chemat Technology, Inc.

Grant Amount: \$75,000

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of developing a polymer membrane for a proton exchange membrane (PEM) fuel cell that is highly proton conductive, water insoluble and stable across a wide temperature range. Polyoxometalate has been proven to have high temperature proton conductivity (0.17 S/cm) and much lower cost than Nafion. Operation at low and high temperature is desirable, because it allows a variety of operating conditions to be used. Low temperature

electrolytes, such as 25 to 60°C, are suitable for portable fuel cells. High temperature electrolyte, 120 to 140°C, is desirable for high power larger fuel cells. High temperature fuel cell reduces the impact of carbon monoxide poisoning in reformat air-fuel cells and allows attainment of high power density. Success in developing alternative, thermally-stable conducting materials could have a tremendous impact on fuel cell technology. By eliminating the hydrous component, it is anticipated that water re-circulation hardware will not be necessary and thermal management issues will be relieved, thus greatly simplifying the overall fuel cell system.

Proposed Outcomes:

- Methodology for producing polymer membranes with the specified characteristics
- Feasibility analysis based on single cell performance testing of the most promising prototype membrane. Fuel Cell Energy will conduct cell testing. Samples will be sent to JPL NASA for evaluation

Anticipated Benefits:

- Increase PEM fuel cell reliability and lifespan
- Reduce PEM fuel cell manufacturing costs by reducing the cost of the membrane from \$500-\$1000/m² for Nafion to \$2/m² for the proposed membrane

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

EVALUATION OF A NEW SOLAR AIR-CONDITIONING SYSTEM

EISG Grant Number: 00-16

PIER Area: Building End Use Technologies

Principal Investigator: William Kopko (703) 323-9578

Organization: WorkSmart Energy Enterprises, Inc.

Grant Amount: \$74,547

Grant Term: 18 months

Project Description: The purpose of this project is to research the feasibility of a solar air-conditioning system that combines a liquid desiccant-based cooler and a low-cost solar collector for regenerating the liquid desiccant. The project will build and test a bench-scale prototype for evaluating a new solar air-conditioning system. The system provides low-cost energy storage, which allows the use of off-peak electricity for backup during extended cloudy periods. The project will involve testing heat-exchanger components, building a protot3Te cooler, measuring the performance of the cooler, building and testing a small solar collector, assembling and testing a complete bench-

scale solar air conditioner, and summarizing the results in a final report. Successful completion of this project will obtain basic component performance data and demonstrate a working bench-scale solar air conditioning system.

Proposed Outcomes:

- Subscale prototype system
- Feasibility analysis based on prototype performance

Anticipated Benefits:

- Reduce AC power consumption by 80% compared to conventional air conditioning
- Competitive installed costs to conventional AC systems

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

DEVELOPMENT OF OPTIMUM DESIGN CONFIGURATION AND PERFORMANCE FOR VERTICAL AXIS WIND TURBINE

EISG Grant Number: 00-17

PIER Area: Renewable Energy Technologies

Principal Investigator: Hamid R. Rahai (562) 985-5132

Organization: CSU Long Beach Foundation

Grant Amount: \$69,781

Grant Term: 12 months

Project Description: The purpose of this project is to research the feasibility of improving the efficiency of vertical axis wind turbines by optimizing the blade design through numerical modeling. Two subscale prototypes will be fabricated and tested, one with an optimized mono airfoil and one with an optimized two element airfoil. The objective of the project is to improve the performance of vertical axis wind turbines for residential and commercial applications. Recent studies suggest that increasing the efficiency of this type of turbine requires increased contribution from the lift force to generate torque. The present proposal will implement numerical techniques for optimizing highly cambered thin airfoils (which have similar shapes as high lift airfoils) for use in a high-efficiency, vertical-axis wind turbine. Using optimized blades, scaled model turbine will then be built and tested in the wind tunnel.

Proposed Outcomes:

- Two subscale prototype wind turbines with optimized blades
- Methodology for optimizing blade designs
- Feasibility analysis based on performance of prototype turbines

Anticipated Benefits:

- Increase vertical-axis wind turbine efficiency by 20 - 30%
- Cost-effective, vertical-axis wind turbines that could be used for distributed generation applications

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

COMMERCIAL AND RESIDENTIAL SUPER INSULATED PHASE CHANGE MATERIAL WATER HEATER**EISG Grant Number:** 00-18**PIER Area:** Building End Use**Principal Investigator:** Nick Wynne (937) 376-8233**Organization:** VacuPanel Inc.**Grant Amount:** \$75,000**Grant Term:** 12 months

Project Description: The purpose of this project is to research the feasibility of developing an innovative electric water heater that increases operating efficiency by incorporating vacuum insulation and phase change materials. This proposal describes an innovative, advanced technology water heater design which uses the advantages provided by vacuum insulation panel (VIP), and phase change material (PCM) technologies to reduce the operating expense and improve the efficiency of maintaining heated water. Energy stored in heated water statically awaits demand throughout the day, and is

frequently wasted due to stand-by losses. The proposed water heater will be designed to optimize the storage of heat in a phase change material (PCM), through which cold water passes to become heated, use VIP to retain the heat in the PCM over a long period and be recharged (heated to change phase) at less expensive, off-peak electricity or natural gas. Such a heater will provide more efficient and lower cost hot water. The operating cost is reduced through off-peak energy savings, reduced stand-by energy losses, and long life.

Proposed Outcomes:

- Full scale prototype hot water heater
- Feasibility analysis based on performance of prototype system

Anticipated Benefits:

- Increase the average water heater life from 7 years to 50 years
- Increase water heater efficiency by 6% by reducing standby losses
- Provide increased ability to shift energy consumption to off-peak hours

Project Status:

- Projected Start date Feb. 1st 2001
- First progress report due 4 months after start date

PROJECTS FUNDED THROUGH THE PIER PROGRAM AREAS – IN-PROGRESS

Residential and Commercial Buildings

End-Use Energy Efficiency

ENERGY EFFICIENT DOWNLIGHTS FOR CALIFORNIA KITCHENS

Contract #: 500-98-020

Contractor: Lawrence Berkeley National Laboratory (LBNL)

Industry Partners: Sacramento Municipal Utility Department (SMUD); Natural Resources Defense Council (NRDC)

Contract Amount: \$648,603

Match Funding: \$ 320,028

SMUD \$150,000

Lithonia Lighting \$150,000

NRDC \$20,028

Contractor Project Manager: Stephen Johnson
(510) 486-4274

Commission Contract Manager: Elaine T. Hussey
(916) 654-5006

Project Description: The purpose of this project is to research, develop and demonstrate low-cost, energy-efficient compact fluorescent (CFL) downlights designed specifically for residential kitchen applications. Kitchen lighting is the largest lighting energy user in Californian homes, accounting for one-quarter of residential lighting operating costs. Therefore, kitchen environments have a large energy savings potential, particularly in new construction.

Successful completion of this project, concluding with a decrease in the price of CFL dimming ballasts that control multiple CFL downlights, will result in overall lower initial costs for CFLs for kitchen lighting, making them more attractive to homeowners. In addition, a 15-25 percent increase in output efficiency will further increase the attractiveness of CFL downlights used to illuminate kitchens, where, typically, brighter than average light is required for food preparation.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by overcoming technical and market issues such as lighting quality, the inability to dim and the high initial costs

for CFLs that have provided barriers to the widespread use of CFLs in the residential sector.

Proposed Outcomes:

- Develop single, dimming, electronic ballasts that controls multiple CFL downlights. Developing single, dimming, electronic ballasts that control multiple CLF downlights will reduce the number of ballasts required for a typical kitchen layout of 4-6 fixtures by 75 to 80 percent. This reduction represents an important technical achievement since the highest contributing cost of a CFL downlight system is the ballasts. In CFL downlights with dimming capability, the cost of the ballast can approach 75 percent of the total luminaire cost. This new system will provide high-quality, high-performance, energy-efficient lighting with a significant decrease in initial costs over current CFL downlights.
- Develop thermoplastic fixtures with high efficiency reflective coatings. Current downlight reflector efficiencies range between 50-70 percent, with the industry standard at approximately 65 percent. The relatively low efficiency of these fixtures is a function of their manufacturing process, which leads to a predominance of rotationally symmetrical reflectors. While these symmetric reflectors are somewhat efficient in optically managing small incandescent sources, they do poorly at handling complex CFL lamps. In contrast, injection molding and other plastic molding processes can generate the complicated, optically efficient geometries that will result in output efficiency increases of 15-25 percent over existing CFL reflectors.

Project Status: The project team has completed Task 1, the Statewide Lighting Survey. The term of the project is from May 1, 2000 to January 31, 2001. The project is on schedule, within budget and is expected to achieve the proposed outcomes.

INCREASED ENERGY EFFICIENCY OF AIR CONDITIONERS THROUGH USE OF ADVANCED POWER ELECTRONICS

Contract #: 500-98-021

Contractor and Major Subcontractors: Energy Savers International and Lawrence Berkeley National Laboratory

(LBNL); Ed Vineyard; Hybrid Circuits, Inc.; Sun Frost; Bristol Compressors; Robert Lynette.

Contract Amount: \$411,614

Match Funding: \$114,714

Contractor Project Manager: Jay Jayadev
(650) 964-1596

Commission Contract Manager: R. Michael Martin
(916) 654-4039

Project Description: The purpose of this project is to develop an energy-efficient electronic control system by which air conditioners and heat pumps with single-phase compressor motors can be operated more energy efficiently using three-phase motors. Because three-phase motors are more efficient and less costly to manufacture, there is a significant potential for reducing the electrical consumption of conditioners and other residential appliances. This project will help decrease the load energy consumption of air conditioners that have a significant effect on peak loads.

Successful completion of this project will significantly increase the efficiency of air conditioners and heat pumps with no increase in cost to consumers. The technology is applicable to other residential appliances that use single-phase motors such as washing machines and clothes dryers, which promises huge energy savings potential for residential appliances.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by making an existing energy technology more efficient, thereby lowering the cost of electricity for cooling and electric heating to residential customers; and
- Improving the reliability/quality of California's electricity by helping to reduce peak electrical demand from residential cooling.

Proposed Outcomes:

- Develop and demonstrate innovative proprietary power electronics to convert single-phase power to three-phase power. Converting to three-phase power significantly reduces conversion losses, making the use of three-phase motors economically feasible for residential applications.
- Purchase and modify compressor, installing it in a conventional design air conditioner.
- Test the energy efficiency of the modified air conditioner compared against an unmodified conditioner

Project Status: The contractor has demonstrated that this technology does work. Testing is now underway to measure precisely how much improvement is achieved at 82°F, 95°F, and 105°F outdoor temperatures

DEVELOPMENT OF AN ADVANCED INDIRECT EVAPORATIVE HEAT EXCHANGER MODULE

Contract #: 500-98-022

Contractor and Major Subcontractors: Davis Energy Group Inc. and Pacific Gas & Electric Co.; Refrigeration Technology Inc.; Cooltech Inc.; and James Ramos & Associates

Contract Amount: \$248,719

Match Funding: \$84,618

Contractor Project Manager: Richard C. Bourne
(530) 753-1100

Commission Contract Manager: Ray Darby
(916) 654-5074

Project Description: The purpose of this project is to design, develop and test an improved heat exchanger for the advanced indirect evaporative cooling stage of the SmartCool™ two-stage evaporative cooler. This indirect heat exchanger will lower the cost of the SmartCool™ unit by 30 percent allow for a range of sizes of the unit, and increase efficiency by an estimated 5 percent. A manufacturing strategy will also be developed.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing an air conditioning technology that contributes considerably less to peak electrical demand than conventional air conditioning units; and
- Improving the energy cost/value of California's electricity by refining a new energy efficiency technology to make it more market ready.

Proposed Outcomes:

- Lower cost heat exchanger design, allowing the manufacturer to drop the contractor price for a complete SmartCool unit from \$1,700 to \$1,200 – the approximate cost of a standard (compressor-based) cooling system of equivalent cooling capacity – making the unit more cost-competitive.
- Thirty percent lower installation costs and 60-80 percent less operating costs than compressor-based cooling.
- Overall efficiency gain of about 5 percent.
- Improved reliability/durability.

Project Status: The project is within budget. The project started late due to the need to identify a new manufacturing partner after the original partner dropped out. The new partner, Des Champs Laboratories, is a well known, major manufacturer of evaporative cooling and heat exchange equipment. The size and capabilities of Des Champs Labs are far greater than the original partner, providing a better match for meeting high-volume manufacturing and other commercialization needs.

CONCEPTUAL DESIGN ENERGY ANALYSIS TOOL

Contract #: 500-98-023

Contractor: GeoPraxis; Artifice Inc.

Contract Amount: \$452,655

Match Funding: Artifice Inc.\$65,060

Contractor Project Manager: Tom Conlon (707) 996-9408

Commission Contract Manager: Tav Commins

(916) 653-1598

Project Description: The purpose of this project is to design and develop an easy-to-use, market transforming energy analysis software module (based on simulation technology) that will be seamlessly integrated with an existing 3-D conceptual building design software tool. The powerful (DOE-2 based) analysis tool will be hidden within the 3-D software tool. Target users will be energy non-experts (primarily architects, design/build contractors, developers) who will be able to generate reliable estimates of the relative energy performance of a new building in its earliest stage of design. The tool's parametric capabilities will allow users to understand and test the energy-related impacts of their designs, including fuel and material choices, system types, orientation, fenestration layout and other key decisions which often become fixed at this early stage of the construction process.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by helping architects, design/build contractors and developers generate reliable estimates of the energy performance of a building while it is still in its earliest stage of design.

Proposed Outcomes:

- Produce a software product which provides annual energy consumption, peak power demand, and annual energy costs for two modeled alternatives: 1) a code-complying building and 2) a "best practice" building.
- Produce a software product that will facilitate the estimation of building energy consumption during the early stages of architectural design.
- Distribute the programs interface specifications and documentation at no cost.
- Produce readiness plan to commercialize the tool.

Project Status: The project is approximately 8 months behind schedule and is expected to be completed in August 2001.

ALTERNATIVES TO COMPRESSOR COOLING, PHASE V

Contract #: 500-98-024

Contractor and Major Subcontractors: Davis Energy Group and University of California, Berkeley Solar Group; Loisos/Ubbelohde; Pacific Gas & Electric; ZTECH; CR Communications.

Contract Amount: \$867,683

Match Funding: \$154,437

Contractor Project Manager: David Springer

(916) 753-1100

Commission Contract Manager: Randel R. Riedel

(916) 654-4109

Project Description: The purpose of this project is to improve the energy efficiency of new single-family homes in California transition (mild) and inland climates, while providing indoor comfort and air quality. This project will develop, construct and monitor two new homes, which use "integrated ventilation cooling" instead of central air conditioning. "Integrated ventilation cooling" combines architectural design features, such as glazing orientation and thermal mass, with the Contractor's integrated Heating, Ventilation and Cooling (HVC) unit and HVC advanced control. The integrated HVC unit combines a fan coil unit, containing a variable-speed fan blower and a hot-water coil for ventilation and heating, with a damper system for nighttime cooling and ventilation. The HVC unit for inland climates may also include a refrigeration coil for cooling. The HVC advanced control optimizes the integrated HVC unit's operation to maintain indoor comfort levels and ventilation rates.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing peak electrical demand created by compressor-based air conditioning; and
- Improving the energy cost/value of California's electricity by reducing energy use and costs created by residential space cooling during summer "heat storms."

Proposed Outcomes:

The HVC unit will include:

- Integrating dampers for night ventilation cooling.
- Fan coils that will heat the house using the domestic hot water.
- A variable speed blower motor for quiet, efficient heating and ventilation and an optional refrigerant coil for compressor-based cooling.
- Advanced controls, which convey the concept of ventilation cooling to the user, will be improved in this project phase.

Project Status: As of 1 March 2001: Task 1 – Project Startup Tasks is 100% complete; Task 2.1 –1 Develop and Test Integrated HVC Unit is 98% complete; Task 2.2 –

Develop and Test Advanced Control system is 85% complete; Task 2.3 – Extend House Design to Inland Climates is 70% complete; Task 2.4 – Install, Commission, Evaluate and Document Prototype Systems is 7% complete; Task 2.5 – Production Readiness Plan is 5% complete; Task 3.1 – Monthly Progress Reports, sixteen progress reports have been submitted; Task 3.2 – Final Report is 0% complete.

HVAC DISTRIBUTION SYSTEMS IN COMMERCIAL BUILDINGS

Contract #: 500-98-026

Contractor and Major Subcontractors: Lawrence Berkeley National Laboratory (LBNL)

Contract Amount: \$537,000

Contractor Project Manager: Rich Wilson (510) 486-4678

Commission Contract Manager: Mazi Shirakh (916) 654-3839

Project Description: The purpose of this project is to obtain the scientific knowledge to properly measure and compare commercial buildings' thermal-distribution-system performance in terms of energy efficiency and indoor air quality. This new information will be applied to designing better thermal distribution systems in new commercial buildings and retrofitting existing systems to reduce their energy consumption and peak-electrical demand. This project will also develop and test LBNL's aerosol-based duct retrofit technologies to determine the extent to which they reduce duct leakage, conduction losses and energy consumption and demand. Approximately one third of the electricity used in California commercial buildings is consumed by heating, ventilation and air conditioning (HVAC) equipment. Research suggests that the HVAC thermal distribution systems in these buildings suffer from a number of problems, such as duct leakage and thermal losses due to poor duct location.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing peak summer HVAC electrical demand;
- Improving the energy cost/value of California's electricity by eliminating the waste from leaky HVAC distribution systems; and
- Improving the environmental and public health costs/risks of California's electricity by improving indoors air quality through sealing HVAC thermal distribution systems.

Proposed Outcomes:

- Collect data on existing commercial buildings for characterizing the buildings' thermal distribution systems performance.

- Develop metrics to benchmark the performance of the thermal distribution systems.
- Develop and test aerosol-sealing technologies and document the effectiveness of this technology for sealing thermal distribution systems.
- Develop techniques for applying duct coating and sealing material in large commercial buildings that include laboratory and field testing of the equipment.
- Conduct outreach efforts to publicize the results of the research to technical, scientific, trade, and regulatory organizations that can utilize the findings.

Project Status: The project is proceeding on schedule.

During the last quarter, the contractor completed the preliminary outlines for the Metrics and Diagnostics and a preliminary In-Situ Characterization plan. This effort included the further development of important metrics and diagnostics protocols. These parameters were presented and discussed during LBNL's Professional Advisory Committee (PAC) meeting in November of 2000. Metrics were developed and presented to the PAC for the following parameters:

- Thermal Comfort and Zonal Acceptability
- Indoor Air Quality
- Energy Performance Metrics

The PAC approved the developed Metrics.

During the next quarter, the contractor will initiate on-site visits and In-Situ Characterization in the field.

BUILDING SPECIFICATION GUIDELINES FOR ENERGY EFFICIENCY

Contract #: 500-98-027

Contractor and Major Subcontractors: Eley Associates and Taylor Engineering; Cathrine Cooper; SMWM; SDV/ACCI; After Image; John Raeber

Contract Amount: \$233,280

Contractor Project Manager: Erik Kolderup (415) 957-1977

Commission Contract Manager: Virginia Lew (916) 654-3838

Project Description: The purpose of this project is to develop reference specifications for specific energy-efficiency equipment or technologies for commercial buildings. The focus is on equipment and technologies that are cost effective to install but for which information is inadequate. This project is envisioned to remove the barriers toward specifying energy efficient equipment and technologies for commercial buildings by:

- Simplifying the specifications of some technologies;
- Addressing project commissioning and monitoring within each of the technologies;

- Providing specifications for advanced cost-effective technologies;
- Addressing integrated controls and open protocols for commercial lighting and heating, ventilating and air conditioning (HVAC) systems; and
- Disseminating the new specifications to the industry through the Internet.

Once the specifications have been tested by the Contractor's team and reviewed by building design professionals, they will be made available through the Internet. The format will facilitate the use and incorporation of the specifications into construction documents by design professionals. In addition, equipment manufacturers will also understand what they need to build to satisfy the efficiency market.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by influencing standard construction practices and future building and system energy use in the commercial sector.

Proposed Outcomes:

- Promote energy efficient design of commercial buildings through actual use of the developed specifications.
- Reduce annual building system (e.g., lighting, HVAC) energy costs of the building whose design used the specifications by at least five percent.

Project Status: Project is on schedule and is within budget. The project is expected to be completed by March 31, 2004.

DESIGN REFINEMENT AND DEMONSTRATION OF A MARKET-OPTIMIZED RESIDENTIAL HEAT-PUMP WATER HEATER

Contract #: 500-98-028

Contractor and Major Subcontractors: Arthur D. Little, Inc. and EnviroMaster International; Manufacturing Associates; Pacific Plumbing

Contract amount: \$756,095

Match funding: \$109,235

Contractor Project Manager: Robert A. Zogg
(617) 498-6081

Commission Contract Manager: Tony Wong
(916) 654-4015

Project Description: The purpose of this project is to design, test and demonstrate a market-optimized residential heat-pump water heater. The primary objectives of this project are to identify and implement design refinements to lower initial and operation costs and increase performance, perform laboratory tests to

demonstrate the durability/reliability of the design, and demonstrate the performance, reliability and ease of installation through a California-based field test.

A.D. Little will provide durability testing on three prototypes for one year under laboratory conditions and will field-test twenty-five prototype units in California residences.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing a low-cost, highly reliable and durable residential heat-pump water heater (HPWH).

Proposed Outcomes:

- Reduce the total installed cost of residential heat pump water heaters from \$1,200 to \$875.
- Design and fabricate a heat pump water heater capable of achieving at least a 2.0 energy factor, the standard performance measure for water heaters using a test procedure prescribed by the U.S. Department of Energy.

Project Status: Due to the cost growths in the refined component design and selection task, additional funding is required to complete the project, particularly the field demonstration phase. Additional funding will come from a combination of increased AD Little match funds and California utilities. The involvement of the California utilities will serve to accelerate market penetration of the commercialized HPWH, a benefit that the original project approach did not provide.

REMOVING THE KEY TECHNICAL BARRIER TO THE WIDESPREAD USE OF ADVANCED ABSORPTION COOLING

Contract #: 500-98-029

Contractor: Gas Research Institute with Stanford Research Institute (SRI) and The Trane Company

Contract Amount: \$690,178

Match Funding: \$235,000

Contractor Project Manager: Kevin Krist, (773) 399-8211

Commission Contract Manager: Bradley Meister
(916) 653-1594

Project Description: The goal of this project is to improve the efficiency and lower the cost of natural gas fired absorption chillers. This project will study and support continuing development of new corrosion resistant materials, applied as a thin diffusion coating on low cost materials of a commercial air conditioning system that uses an advanced absorption chiller. After diffusion coatings are selected, generator and absorber components will be tested in individual sub-scale absorption chiller

Project Description: The purpose of this project is to develop and assess energy-efficient power management interface standards adaptable to a variety of office

equipment and appliances used in commercial buildings. Electricity savings from the power management of office equipment has been one of energy efficiency's premier success stories. Despite this success, many devices that are capable of power management are not saving energy because the power management features are disabled, incorrectly configured, or thwarted by a hardware or software conflict. The goal of this project is to capture energy savings by increasing the rate at which power management is enabled and operates successfully.

Technical challenges include identifying interface elements that people find the clearest and simplest, and a system which meets the needs of all manufacturers. The U.S.DOE and the U.S.EPA have, through the ENERGY STAR Program, committed their institutional resources to ensuring the active participation of industry. However, the standard will be voluntary – no company will be required to use it – and can be adhered to entirely or partially by manufacturers. This approach allows gaining the benefits of a standard while retaining flexibility for manufacturers that believe that they can improve on the interface, or have a product with unique or unanticipated features.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by improving the energy efficiency of commercial-sector office equipment and appliances.

Proposed Outcomes:

- Design, develop and test a new, standard user interface for office equipment power management which is acceptable to electronic equipment manufacturers, standards organizations and the U.S. EPA's ENERGY STAR program for voluntary adoption.

Project Status: Contractor has completed task 2.1 and passed the first critical project review.

INSTRUMENTED HOME ENERGY RATING AND COMMISSIONING

Contract #: 500-98-033

Contractor: Lawrence Berkeley National Laboratory (LBNL)

Contract Amount: \$710,000

Match Funding: \$137,000

Contractor Project Manager: Max Sherman
(510) 486-4022

Commission Contract Manager: Dale Trenchel
(916) 654-4098

Project Description: The purposes of this project are to

demonstrate the value that building commissioning services would have on new and existing residences in California and to develop residential building commissioning guidelines. These guidelines will lay the groundwork for a residential commissioning industry to provide commissioning services. The energy performance of the most significant components of a building will be evaluated, and the diagnostics and audit tools developed will be for use in commissioning.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by helping consumers optimize the energy systems in their home to perform at peak energy efficiency;
- Optimizing consumer choice of home energy saving technologies; and
- Maximizing market/economy connection by making use of a project advisory committee with participants from the building industry, home energy rating professionals, HVAC representatives, utilities and government.

Proposed Outcomes:

- An annotated bibliography on current building commissioning research.
- A metrics and diagnostics report with recommended diagnostic protocols and auditing tools for commissioning.
- A field study report identifying potential energy savings from residential commissioning.
- Commissioning guidelines for new and existing houses.
- User workshops to inform the buildings, services, regulatory and professional communities of the guidelines and improve their content and clarity.

Project Status:

- The annotated bibliography on building commissioning is complete.
- The draft metrics and diagnostics report is complete with the final report scheduled for completion by mid-April, 2001.
- The laboratory and field study work is complete and the draft report will be completed by mid-April, 2001.
- Commissioning guidelines are being prepared with draft guidelines to be completed by mid-April, 2001.
- Three PAC meetings have been held with a final meeting planned for mid-May, 2001.
- User workshops have not been initiated, but are under consideration.
- The project draft final report is due November 1, 2001.

INVESTIGATION OF SECONDARY LOOP SUPERMARKET REFRIGERATION SYSTEMS

Contract #: 500-98-039

Contractor and Major Subcontractors: Southern California Edison and Foster-Miller

Contract Amount: \$300,000

Match Funding: \$150,000 (Safeway/Vons Inc.)

Contractor Project Manager: Ramin Faramarzi, P.E.
(626) 633-7168

Commission Contract Manager: Nelson R. Peña
(916) 654-4217

Project Description: The purpose of this project is investigate the use of an advanced secondary loop system that will circulate a refrigerated brine solution from a chiller to refrigeration equipment display cases in supermarkets. The project will identify possible system improvements such as variable-speed pumping, evaporative condensing, subcooling and low-head pressure operation that will reduce energy consumption in supermarkets. The existing refrigeration equipment display cases in an existing supermarket will be instrumented to measure baseline performance. A second new store, using an advanced secondary loop system, will also be instrumented, and a field test of both systems will be conducted where performance and energy consumption of each system will be compared. The secondary loop refrigeration systems can significantly reduce the refrigerant charge in supermarkets, which promotes substantial environmental benefits by protecting the ozone layer and inhibiting global warming.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by developing an alternative refrigeration system, which uses significantly less ozone-depleting refrigerant than conventional refrigeration systems; and
- Improving the energy cost/value of California's electricity by lowering electrical consumption of supermarket secondary loop refrigeration systems.

Proposed Outcomes:

- Reduce energy consumption for refrigeration or freezing in supermarkets by approximately 13.9 percent.

Actual Outcomes: The project is ahead of schedule and under budget. Work is expected to be complete by April 4, 2002.

CENTER FOR THE BUILT ENVIRONMENT (CBE)

Contract #: 400-99-001

Agency Partners: Armstrong World Industries; California Department of General Services; Henningson, Durham & Richardson, Inc.; International Facility Management Association; Johnson Controls, Inc.; Lucent Technologies; Ove Arup & Partners, Ltd.; Pacific Energy Center; Tate Access Floors, Inc.; U.S. Department of Energy; U.S.

General Services Administration; the Webcor Team (Alfa Tech Consulting Engineers, Critchfield Mechanical, Rosendin Electric, and Webcor Builders); and York International Corporation.

Contract Amount: 1999: \$30,000 2000: \$30,000

Total Contract: \$60,000

Match Funding: 1999: \$498,750 2000: \$498,750

Total Match: \$997,500

Principal Project Manager: Kevin Powell, CBE
Administrator (510) 642-4950

Commission Project Manager: Elaine Hebert
(916) 654-4800

Project Description: The purpose of this project is to participate in the Center for the Built Environment (CBE), a university/industry/government collaborative based at the University of California, Berkeley (UCB) campus. CBE performs research in the areas of energy efficiency in buildings, the comfort of building occupants, healthy indoor air quality, and environments conducive to occupant productivity. Through studies of ventilation strategies, air flow, occupant productivity, computer-based occupant feedback mechanisms, space arrangement, and other factors, CBE intends to generate beneficial building and human response data to disseminate to architects, designers, mechanical and building engineers, government agencies, and other entities involved in creating indoor environments.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by encouraging energy efficiency in the heating, cooling, ventilation, and lighting of buildings; and
- Improving the environmental and public health costs/risks of California's electricity by reducing pollution associated with electricity generation through encouraging the efficient use of energy in buildings and providing healthier indoor environments by improving indoor air quality.

Project Status: Research is on schedule and within budget. One project, underfloor air distribution systems, has been receiving a great deal of interest from CBE partners and non-partners and is expanding to accommodate this unanticipated added interest. CBE is seeking funding from additional sources to support new scopes of study including an expanded energy focus.

Some recent CBE accomplishments include: 1) a web-based survey tool which enables building owners and operators to manage their buildings more efficiently has been adopted by the US General Services Administration; and 2) a project that developed a control algorithm for improved response to hot/cold complaints in office

buildings has produced a published paper, and the algorithm is currently being field tested.

NSF recently awarded CBE and two other UC Berkeley research centers \$1.1 million to increase the scope of work on distributed wireless sensing. This project will study improved indoor environmental controls in buildings under a variety of conditions and potentially yield substantial energy savings. ASHRAE is co-funding a new project to investigate whether comfort standards can be relaxed for buildings with operable windows; energy savings could be realized through reduced use of mechanical heating and cooling.

ENERGY EFFICIENT AND AFFORDABLE SMALL COMMERCIAL AND RESIDENTIAL BUILDINGS PROGRAM

Contract #: 400-99-011

Contractor and Major Subcontractors: Architectural Energy Corporation (AEC) and Battelle-Pacific Northwest Division; The National Institute of Standards and Technology (NIST); Purdue University; Massachusetts Institute of Technology (MIT); Oak Ridge National Laboratory (ORNL); Schiller Associates; Heat-Timer Corporation; and Newport Design Consultants.

Contract Amount: \$1,747,000 (year 1)
\$1,816,000 (year 2)
\$1,859,000 (year 3)

Match Funding: \$2,541,000
\$2,108,000
\$1,738,000

Total Contract: \$5,422,000

Total Match: \$6,387,000

Contractor Project Manager: Vernon Smith
(303) 444-4149

Commission Contract Manager: Bryan Alcorn
(916) 654-4222

Project Description: The purpose of the Energy Efficient and Affordable Small Commercial and Residential Buildings Program is to develop, demonstrate and deploy science and technology solutions for building energy end-uses. The goal of the project is to substantially increase the energy efficiency of California's existing and future building and housing sector. Solutions that provide direct and tangible benefits to California ratepayers will be researched. Key to achieving high impacts and direct benefits for every research dollar are projects that are synergetic, market-oriented, and supported by industry.

The Energy Efficient and Affordable Small Commercial and Residential Buildings Program will investigate the energy

efficiency of buildings and will develop and demonstrate programs to improve energy efficiency. The program will address such issues as peak electrical demand, the need for better indoor environments, and the need to make California's commercial buildings and residential homes more affordable. It will also strengthen the growing energy efficiency industry in California by providing new jobs and growth opportunities for companies that provide the technology, systems, software, design, and building services to the commercial sector.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective; and
- Improving the reliability/quality of California's electricity by reducing peak demand and improving load factor, leading to reduced infrastructure costs and system reliability risks.

Project Status: The program is progressing well, however, the prime contractor experienced difficulties securing contracts with the five key sub-contractors. As a result, the program has fallen behind schedule approximately three to four months. This schedule shift has caused some of the data collection projects, which rely on seasonal information, to wait till the following heating or cooling season. There is currently an effort under way to accelerate some of the individual project deliverables to minimize impacts to the overall schedule.

INTEGRATED ENERGY SYSTEMS PRODUCTIVITY AND BUILDING SCIENCE PROGRAM

Contract #: 400-99-013

Contractor and Major Subcontractors: New Building Institute (NBI) and Heschong Mahone Group; Eley Associates, Inc; Architectural Energy Corporation; GARD Analytics, Inc; RLW Analytics, Inc; SBW Consulting; Hamphill Industrial Technologies; Xenergy; M. Neils Engineering, Inc; Taylor Engineering; Florida Solar Energy Center; Energen Consulting, Inc.; Clanton Engineering, Inc; Cascadia Conservation; Energy, Environ, Economics; SDV/ACCI; Northwest Evaluation Associates; Tate Solar; Oakridge National Laboratories; Benya Light.

Contract Amount: \$1,949,255 (year 1)
\$1,995,950 (year 2)
\$1,937,848 (year 3)

Total Contract: \$5,883,053

Contractor Project Manager: Peter M. Schwartz
(415) 924-1442

Commission Contract Manager: Donald Auman

Project Description: The purpose of the Integrated Energy Systems Productivity and Building Science Program is to promote improvements to productivity or building science based on integrated systems research. Each element is designed to fill major gaps in the existing body of building science knowledge. It is not the individual element, but how they are assembled into and operated within a building system, that determines energy efficiency.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective; and
- Improving the reliability/quality of California's electricity by reducing peak demand and improving load factor, leading to reduced infrastructure costs and system reliability risks

Project Status: The contract was signed on August 17, 2000, a delay of several months from the previously anticipated start date due to contract development issues. This delay impacted initial plans for field-site monitoring during specific heating and cooling seasons. The contractor is revising the schedule of deliverables to meet contract-timing needs.

The contractor has signed subcontracts with all element leads and work has begun on several program elements, including:

- A Project Advisory Council (PAC) meeting was held February 13, 2001.
- The contractor has established a program web site.
- Several Technical Advisory Council meetings have been held.
- In Element 2, Productivity and Interior Environments, the research team conducted analysis of daylighting impacts in schools and is preparing a conference paper to disseminate the results.
- In Element 3, Integrated Design of Large Commercial HVAC Systems, the contractors are identifying field sites to conduct field studies.
- A revised schedule is being developed to accelerate tasks in the upcoming year.

Industrial / Agricultural / Water End-Use Energy Efficiency

RECYCLING CHILLER-BATH RINSE WATER IN POULTRY PROCESSING

Contract #: 500-98-030

Contractor and Major Subcontractors: WaterTech Partners

Contract Amount: \$440,400

Match Funding: \$144,000

Contractor Project Manager: Ronald Enzweiler
(925) 283-4918

Commission Contract Manager: Ricardo Amon
(916) 654-4019

Project Description: The goal of this project is to reduce the energy required in poultry processing by demonstrating the feasibility of using ozone water treatment technology to recycle chiller bath rinse water in poultry processing operations. Presently, poultry processors use chlorine chemicals to disinfect the chiller-bath step and must discard the 0.5 gallons of chilled, chlorinated rinse water used per bird to meet USDA sanitary regulations.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity to electric ratepayers by reducing energy use or improving energy efficiency in the industrial sector; and
- Improving the environmental and public health costs/risks of California's electricity by avoiding the use of chlorine disinfectants.

Proposed Outcomes: Using the Mobile Treatment Demonstration Unit (MTDU) provided by EPRI, a feasibility test at the Foster Farms Poultry Processing Plant in Livingston, California will:

- Demonstrate that ozone is an effective antimicrobial sanitizer in poultry processing which can be safely used in direct contact with the birds and that ozone does not create any harmful by-products or side effects.

Upon obtaining U.S. Department of Agriculture (USDA) approval for a pilot-test program, WaterTech partners will

- Design, install and operate a closed-loop, ozone-based pilot recycling system at a Petaluma, California poultry processing chiller line for six months. Successful pilot-scale testing is expected to result in USDA approval for replacing chlorine with ozone in the chiller-bath process of the poultry-processing industry.

- Achieve energy savings by returning the filtered and disinfected chiller-bath overflow water to the heat exchanger used to chill water for the chiller bath. Since the average temperature of the feed water will be reduced to about 50 degrees F from 75 degrees F, the refrigeration load will be dramatically reduced which will lower overall system energy requirements.
- Achieve estimated net energy savings of 3 million kWh per year of energy (about 12 watts/bird) in the 250-million-bird-per-year poultry processing industry in California.

Project Status: Chilled bath and the MTDU trailer will be installed at Petaluma Poultry facility to conduct USDA approved pilot test project. Data collection and evaluation will be conducted during the 2001 summer season. Results will be available by December 2001.

ENERGY EFFICIENT AGRICULTURAL TECHNOLOGIES

Contract #: 400-99-005

Agency Partners: University of California, Davis (UCD)

Commission Funding: \$1,793,000

UCD Project Manager: Jim Thompson (530) 752-6167

Commission Project Manager: Ricardo Amon
(916) 654-4019

Project Description: The purpose of this project is to demonstrate the use of ozone as a substitute soil fumigant to replace chemical pesticides and as an alternative to aqueous toxic chemicals for fungi control in fruit packing plants. In addition, the project will investigate irrigation scheduling systems, precision farming technologies and innovative manure treatment technologies.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficiency of emerging electrotechnology applications in agriculture; and
- Improving the environmental and public health costs/risks of California's electricity by replacing toxic chemicals used in agribusiness with cleaner electrotechnologies.

Project Status: The project is on schedule, within budget and is expected to achieve its goals. The contract term is from September 1, 1999 through December 31, 2004.

TARGET 23/2.6 CHEMICALS, PETROLEUM AND NATURAL GAS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Advanced Resources International, Inc; Chemicals & Petroleum Management, Inc.; Edison Technology Solutions; El Paso Energy Corp.; Hawaiian Electric Company Inc; Kennedy/Jenks Consultants Inc; Lockheed Martin Energy Research Corporation; Massachusetts Institute of Technology; Niro Process Technology; Taratec Corporation; University Of Florida; University of Patras; Veritech, Inc; ISOPro International; Optima Engineers & Co.; ProWrite Inc.; Resource Dynamics

CEC Project Amount: 1999: \$195,038
2000: \$253,140
Total: \$448,178

Match Funding: 1999: 582,206
2000: \$584,321
Total: \$1,166,527

Contractor Project Manager: Ammi Amarnath
(650) 855-2548

Commission Project Manager: John Sugar
(916) 654-4563

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide chemical and petroleum companies methods to cut energy costs while improving productivity and yield. It will also provide information for companies reviewing options for generating on-site electricity and seeking the latest and most cost-effective advances in pollution control. To stay productive and profitable, decision-makers in this market sector must address a host of economic and environmental concerns. EPRI provides information and technical expertise on advanced systems for wastewater reduction, soil remediation, and fluid transport to increase the value of electricity as this segment of California industry enhances environmental compliance and lowers operating costs.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing information on reducing wastewater discharge and improving soil remediation techniques for the chemical, natural gas, and petroleum industry; and
- Improving the environmental and public health costs/risks of California's electricity by providing information to reduce the impacts on the environment by the chemical, natural gas, and petroleum industry.

Proposed Outcomes:

1. Encourage the use of ozonation in process industries

through a demonstration project at an industrial site in California.

2. Improve the understanding of power quality needs of large industrial complexes.
3. Provide information to encourage reduction of wastewater for process industries.
4. Provide marketing and communication tools to increase use of energy efficient technology in chemicals and petroleum process.
5. Provide information to increase use of energy efficient technologies in chemical, natural gas, and petroleum processes.
6. Conduct a Tailored Collaboration entitled "Development and Demonstration of Liquid Membrane Technology for MTBE Mitigation in Aqueous Streams" for the reduction and removal of MTBE contamination in the California water supply.
7. Conduct a Tailored Collaboration entitled "Hydrogen Pinch Studies at Arco's Wilmington (CA) Refinery" in order to identify process and equipment changes to improve hydrogen recovery in the most cost-effective way.

Actual Outcomes:

1. This proposed outcome was replaced by the Tailored Collaboration entitled "Characterizing Power Quality and Specifying Solutions at a Food Processing Plant" conducted under EPRI Target 38, Power Quality for Improved Industrial Operations.
2. This proposed outcome was replaced by the Tailored Collaboration entitled "Hydrogen Pinch Studies at Arco's Wilmington (CA) Refinery" and described in item #7 below.
3. Wastewater reduction.
 - A comprehensive report was published that identifies and characterizes current and potential water management technologies.
 - A Water Management Workshop was held in conjunction with EPRI's AIChE's Center for Waste Reduction Technologies.
4. The Supply Side Management Kit was produced, including brochures, guidebooks, case studies, and other promotional and education materials regarding electricity and gas sales, distribution system reliability, cogeneration, tariff analysis, and asset management.
5. Information to increase use of energy efficient technologies.
 - A scoping study report was published on enhanced oil recovery technologies.
 - A report was published on Pinch screen analysis to maximize process energy efficiency.
 - A report was published about a promising membrane process that delivers environmental and economic benefits by recovering valuable feedstocks in polyolefin plants.

- A TechApplication document was published outlining the economics and emission reduction advantages of electric compression for natural gas storage and pipelines.
 - Market and technical information were compiled about a major business trend in the chemicals industry—the move into the high-margin segments of life sciences and specialty chemicals.
 - A report was published on trends, issues, and opportunities in healthcare.
 - A monthly newsletter was published on industrial trends and developments.
 - The Third Gas/Electric Partnership Symposium was held, bringing together representatives from electric power, gas pipeline, and service industries to pursue partnerships.
 - An overview course was presented on the petrochemical industry.
6. Development of the liquid membrane technology is still in progress.
 7. For a new methodology called Hydrogen Pinch, the project team collected and analyzed data at Arco's refinery in Los Angeles, and made recommendations for applying the methodology in efforts that could yield a total annual savings for the refinery of about \$4.5 million. A report was published, and workshops are under way.

Project Status: The Commission's participation in this target is ongoing.

TARGET 35/6 CUSTOMER POWER CONDITIONING SOLUTIONS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Power Electronics Applications Center; Adjustable Speed Drive Demonstration Office Maxwell Technology (CA); Trinity Flywheel Corp. (CA); DCH Technology (CA); Pillar Flywheel Co.; Active Power; Electrotech; (CA); Urenco (England); Oregon State University; Precise Power Corp; Teco-Westinghouse; University of Texas, Austin; Power Cell Co.

CEC Project Amount: 1999: \$476,250
2000: \$341,250
Total: \$817,500

Match Funding: 1999: \$1,416,014
2000: \$2,381,223
Total: \$3,797,237

Contractor Project Manager: Ben Banerjee
(650) 855-7925

Commission Project Manager: Pramod Kulkarni

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address the power quality (PQ) issues facing commercial and industrial energy users who are using devices that are more sensitive to PQ variations. Sensitive loads often are in extensive networks and automated processes, and many larger loads use power electronics for power conversion. These new, technology-driven changes have created a growing concern in many California businesses about the quality of power and its potential negative impact on productivity, downtime costs, and lost product. These concerns focus on power quality mitigation equipment, that is, power conditioning equipment that can protect loads from PQ variations.

EPRI research efforts have identified voltage sags and momentary interruptions as the two most important categories of California's power quality variations affecting end users. Traditional power quality mitigation technologies such as uninterruptible power supply (UPS) systems can effectively address these problems, but at a substantial cost. EPRI's Target 35 provides information about the best and most cost-effective power conditioning equipment available, and the technical expertise to help California ratepayers use the equipment properly. This target provides information on power conditioning issues, along with guidance on the proper selection, application, and installation of power conditioning equipment. It also identifies and demonstrates new and innovative technologies with high commercialization potential such as Advanced Flywheels, Advanced Voltage Regulator/UPS and Line Fault Protector, and Voltage Sag Ride-Through Devices.

State-of-the-art power electronics provide higher-performing solutions, integrating voltage regulation for entire customer loads, and UPS for a defined priority load. Built-in load management allows customers to prioritize loads to keep all loads supported through voltage sag and critical loads supported through an extended outage. The price point is very attractive when compared to existing UPS or voltage regulator systems. Using an advanced voltage regulator/UPS and line fault protector to power equipment through voltage sags and momentary interruptions could eliminate California industry and ratepayer power quality interruptions.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by providing knowledge to California ratepayers about how to mitigate power quality problems that cause equipment failures.

Proposed Outcomes:

1. Provide California ratepayers the opportunity to apply the advanced flywheel, a cost-effective energy storage technology, to ride through power quality events.
2. Provide California ratepayers the opportunity to apply the supercapacitor, a cost-effective energy storage technology, to ride through power quality events.
3. Provide California ratepayers the opportunity to apply the advanced voltage regulator/UPS and line fault protector, cost-effective energy storage technologies, to ride through power quality events.
4. Reduce the cost of power conditioning.
5. Conduct a Tailored Collaboration entitled "Determining the Power Quality Implications on Distribution Grid of Disbursed Electric Motors Prevalent in California's Oil Fields."

Actual Outcomes:

1. A comprehensive assessment was made of the feasibility of commercializing high-power/high-energy density flywheel batteries for uninterruptible power supply (UPS) systems for electricity customers and electricity suppliers.
2. Test results indicated that advanced power conditioning technologies such as supercapacitors could be integrated into the power supply of advanced machine tools to mitigate the effects of voltage sags, provide ride-through, and replace batteries used to maintain controller memory.
3. Several outcomes to provide ride-through power quality.
 - A new power-conditioning device—a hybrid adjustable voltage regulator/uninterruptible power supply (AVR/UPS) was developed and tested. This novel device is the first tool in the US and abroad to provide separate voltage regulation and UPS function to distinct loads from one power line conditioner.
 - An evaluation showed that advanced fuel cells have advantages over traditional UPS systems for short-term ride-through of voltage sags and momentary interruptions, and offer long-term back-up power not available from other systems.
 - A preliminary design was made of a medium-voltage dynamic sag corrector, and an assessment was made of the product's market potential and cost.
4. Several outcomes to reduce the cost of power conditioning.
 - A report compiled up-to-date information on current and projected prices for power quality mitigation equipment and the most significant market barriers to cost reductions.
 - A methodology was developed to accurately estimate life-cycle costs for mitigation equipment options.
 - Information was compiled on the power conditioning needs and mitigation hardware for the telecommunications industry.
 - An evaluation was made of the characteristics and system compatibility issues related to a new generation

of power quality hardware for alternate energy systems, load leveling, and motor starting. An integration of supercapacitors and fuel cells has been completed and tested, and a high-speed flywheel and drive were installed and tested.

5. Power quality implications of electric motors in oil fields.
 - A press release was posted on the web to announce the project.
 - A report was published to provide a tutorial on components and artificial lifts typically associated with small oilfield operations.
 - Oilfield tours were conducted at six sites, including THUMS, Tideland, McPherson, OxyUSA, San Joaquin Management, and Holmes. A report was published summarizing findings from the tours.
 - A draft site survey questionnaire document was completed and posted on the web.
 - Additional tasks—including workshops and reports—are to be completed.

Project Status: The Commission's participation in this target ended as of December 31, 2000. Participation in the Tailored Collaboration is ongoing.

TARGET 38/10 POWER QUALITY FOR IMPROVED INDUSTRIAL OPERATIONS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Duke Energy Corporation; Electrotek Concepts, Inc; EPRI PEAC Corporation; Global Software Resources, Inc.; Jacobs Engineering Group, Inc.

CEC Project Amount: 1999: \$447,096
2000: \$341,250
Total: \$788,346

Match Funding: 1999: \$1,273,975
2000: \$1,721,939
Total: \$2,995,914

Contractor Project Manager: Sid Bhatt (650)855-8751

Commission Project Manager: Pramod Kulkarni

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address problems of power quality for the modern, highly automated industrial plants in California that suffer from breakdowns and lost productivity due to voltage, current, or frequency variations within the plant. Power quality (PQ) problems on the utility lines or within an industrial plant can cause equipment failure; damaged products; unsafe working conditions; and wasted time, material, and labor. With today's global competition and increasingly sophisticated and computer-controlled manufacturing processes, industries demand a reliable source of

electricity. Energy companies and customers alike need up-to-date information, technology, and training if both are to remain competitive.

This target offers a complete package of data, information, and knowledge addressing power quality concerns at industrial plants. EPRI products are designed to reduce analysis and engineering time, labor costs, and investigation expenses. Information and training programs serve to educate utility and industrial customer power quality personnel on how to avoid power quality problems by characterizing specific systems. Economic analysis of solution options allows California industry to select the right solution for the PQ problem at hand at the right cost.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by helping California industry more quickly identify the causes of power quality problems, understand the various options for solutions and costs of implementation, and then select the option that best fits the need; and
- Improving the energy cost/value of California's electricity by reducing the impacts of power quality problems by providing cost-effective and fast solutions.

Proposed Outcomes:

1. Provide experiential data on past power quality problems and solutions.
2. Provide information services and support for industrial-sector power quality.
3. Provide a power quality solution package for voltage sags.
4. Focus power quality improvement efforts, resources, and services more effectively for specific industries.
5. Evaluate retrofit capabilities for hardening drives/process equipment to increase the immunity of industrial customers to voltage sags and interruptions.
6. Provide information on field demonstrations of power quality mitigation technologies at industrial customer sites.
7. Provide information on industry-based power quality standards.
8. Conduct a Tailored Collaboration entitled "Characterizing Power Quality and Specifying Solutions at a Food Processing Plant" to document, evaluate, and identify solutions for power quality problems experienced by food processors.
9. Conduct a Tailored Collaboration entitled "Characterizing the Impact of Power Quality on Programmable Logic Controllers with and without Power Conditioning Devices" to develop technical guidelines to quantify the benefits of power conditioning with programmable logic controller (PLC) systems.
10. Conduct a Tailored Collaboration entitled "Power Quality Solution Guidebook for Industrial Customers" to develop a technical guidebook to help consumers identify power conditioning and other mitigation technologies that can increase industrial process immunity to voltage sag disturbances.

Actual Outcomes:

1. Experiential information.
 - A brochure and case studies were provided to help industrial customers improve ride-through and immunity to everyday disturbances.
 - An application brief was provided on application of large flywheel energy storage systems for premium power.
 - A review was completed of new harmonic mitigation technology application case studies.
2. Power quality information and services.
 - Workshops and training sessions were offered on Power Quality for Business Professionals, Power Quality Business Opportunities, Power Quality Technical Training, Power Quality Basics, Intermediate Technical Training, Advanced Power Quality, Residential Shocking, and Adjustable Speed Drive Applications.
 - A quarterly newsletter was published on power quality issues and solutions, and a monthly newsletter was published on EPRI power quality activities and events.
 - Access was provided to power quality expertise, training, and technical support from the EPRI PEAC Corporation and the EPRI Adjustable-Speed Drive Demonstration Office.
3. Version 1.0 was released of EPRI's Industrial Voltage Sag Investigator software tool that allows users to assess problems and identify solution options.
4. Information for specific industries.
 - A comprehensive guidebook was published on power quality mitigation technologies, including a description of each mitigation tool and its application.
 - An Industrial Design Guide, a browser-based information service, was established to provide a guide to power quality issues and case studies on specific processes.
5. Retrofit capabilities for increasing immunity to power quality disturbances.
 - A step-by-step application guide was published for increasing industrial equipment immunity.
 - An overview was provided of embedded solutions for reducing the sensitivity of equipment to power quality variations, focusing on technical and market issues associated with equipment modifications by original equipment manufacturers to improve equipment tolerance to power quality events.

6. Information on field demonstrations.
 - A screening tool was developed for conducting technology demonstrations for industrial customers to increase understanding and build customer confidence in products.
 - A technical document was published that provides step-by-step directions for conducting harmonic mitigation demonstration projects for industrial customers.
7. Up-to-date information was provided on domestic and international industry standards activities, including NEMA, SEMI, NEC, and others.
8. Power quality was monitored at a selected food processing plant, data were analyzed using the EPRI Power Quality Diagnostic System Software, and findings were published in a report.
9. Tests were conducted with and without power conditioning equipment—including testing for voltage sags, capacitor switching transients, and lightning-induced transients. Findings were published in a report.
10. The *Industrial Power Quality Guidebook* was published, with associated web-based HTML pages.

Status: The Commission's participation in this target is ongoing.

INDUSTRIAL WASTE PROCESSING (#825)

Contract #: 100-98-003 (#3)

Contractor and Major Subcontractors: Gas Technology Institute (GTI), TDP -Changing World Technologies (CWT), Sewage Sludge - MicroGas, Inc., Cement Lock - Endesco Clean Harbors, LLC.

Contract Amount: 1999: \$75,000 2000: \$29,000

Contractor Project Manager: Ron Edelstein
(847) 768-0898

Commission Contract Manager: John Sugar
(916) 654-4563

Project Description: The purpose of this project is to develop energy-efficient processes that reduce the cost and energy consumption associated with the treatment and disposal of industrial, commercial, and residential waste streams. Major activities under this project are placed in two categories. The first focuses on a cement-lock technology process that will convert contaminated sludge into environmentally safe cement. This technology could reduce the disposal cost of contaminated materials by \$25 per ton. The second, an advanced Thermo-Depolymerization (TDP) process to convert organic waste into graphite and oil for industrial and commercial use, is in the early stages of development. If successful, a pilot test facility will develop data for full-scale waste reduction in food processing, petroleum, tires, plastics, municipal solid waste, sewage sludge, and animal husbandry.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by providing a process to convert contaminated sludge into environmentally safe cement.
- Improving the energy cost/value of California's electricity by reducing the energy used for disposal of contaminated sludge and organic waste by California energy consumers.

Proposed Outcomes:

1. TDP: Demonstrate the technical feasibility of direct conversion of organic wastes in the food, paper/pulp and tire industry to middle distillates, fatty acids and power.
2. Sewage Sludge: Design and construct a two-ton per day pilot plant for converting sewage sludge in the Seattle area.
3. Cement Lock: Produce a validated cement-locking process technology for a variety of contaminants and a first commercial site to prove the technology. Conversion of Resource Recovery and Conservation Act (RCRA) class III estuarine sediments to Portland cement.

Actual Outcomes:

1. TDP: A 7.5 tons per day (tpd) pilot facility located in the Philadelphia Navy Yard is operational and turbines are connected to the grid.
2. Sewage Sludge: GRI, microGas, Inc. and the city of Seattle teamed to build a 2 tpd pilot unit. The unit is operational. Data is being collected and the technology is under evaluation by the city of Seattle for incorporation into their Reton facility.
3. Cement Lock: A demonstration facility has been sited in New Jersey during the fourth quarter of 2000. The first commercial unit has been sold to Taiwan.

Project Status: Efforts are within budget and on schedule for the TDP and Sewage Sludge Processing tasks. There were some permitting process delays that slowed progress on the Cement Lock siting, but the problems have been overcome, and the facility is expected to be operational by the Spring of 2001.

HIGH EFFICIENCY STEAM GENERATION (#1218)

Contract #: 100-98-003 (#4)

Contractor and Major Subcontractors: Gas Technology Institute (GTI), Ultra-Low NOx Retrofit Boiler Burner - Coen Company (California), FIR (Forced Internal Recirculation) Low NOx Burner – GTI Performing Laboratory (formerly the Institute of Gas Technology), Methane deNOx – Biomass – Detroit Stoker

Contract Amount: 1999: \$37,500
2000: \$37,500

Contractor Project Manager: Ron Edelstein
(847) 768-0898

Commission Contract Manager: John Sugar (654-4563)

Project Description: The purpose of this project is to develop high-efficiency, ultra-low NO_x emission technologies for industrial packaged boilers. The major activity under the project is the complete field trials of low and ultra-low NO_x boiler burners.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by utilizing natural gas-fired low and ultra-low NO_x emission technologies; and
- Improving the public health costs/risks of California's electricity by advancing the efficient use of low-emission natural gas.

Proposed Outcomes:

1. Ultra-Low NO_x Retrofit Boiler Burner: The ultimate goal of the project is to develop industrial boilers with efficiencies above 90 percent and NO_x emissions below 5 ppm. Complete a field installation in a Department of General Services (DGS) building in the Sacramento area.
2. FIR Low NO_x Burner: Develop an ultra-low NO_x burner without external flue gas re-circulation to achieve under 9 ppm NO_x. The long-term target is to reach below the 5-ppm NO_x level. Applications are targeted for boilers and various industrial process heaters.
3. Methane deNO_x – Biomass: Expand the gas reburn technology to stoker-fired boilers using various E-fuels, wastes, and biomass and demonstrate that Methane deNO_x can be a low cost approach to bring solid fuel boilers into environmental compliance while offering many operational benefits.

Actual Outcomes:

1. Ultra-Low NO_x Retrofit Boiler Burner: Sub-5 ppm NO_x achieved at Coen's California boiler test facility. The installation at the State of California's DGS central heating plant in Sacramento, with target of <9 ppm, was completed. All performance targets exceeded design parameters.
2. FIR Low NO_x Burner: Burner sizes at 2.5, 6, and 20 million Btu/hr have been developed. The 6 and 20 million Btu/hr burners have shown 10-15 ppm NO_x in a boiler in Monroe, Michigan. The demonstration of a 2.5 million Btu/hr burner performing at 9-15 ppm NO_x in a packaged boiler at Vandenburg Air Force Base in Southern California is completed. A 60 million Btu/hr burner test at Miller Brewery showed 10 ppm NO_x performance after modifications to burner-to-boiler seal were made.
3. Methane deNO_x – Biomass: The field test at the Boise Cascade plant was successfully completed in 2000 to show that Methane deNO_x can reduce 40-50% NO_x with 10-15% natural gas. All performance goals were achieved.

Project Status: The Ultra-Low NO_x Retrofit Boiler Burner project was successfully completed. New efforts have been initiated under the FIR Low NO_x Burner project to reduce NO_x levels to below 5 ppm and to demonstrate an application on a US Steel industrial boiler cofiring blast furnace gas, coke oven gas, or mixed fuels. For the Methane deNO_x – Biomass project, a performance database is under development, and work will continue on expanding the Methane deNO_x technology to other engineered-fuel applications.

Renewable Energy Technologies

NEXT GENERATION WIND TURBINE DEVELOPMENT PROJECT

Contract #: 500-97-032

Contractor and Major Subcontractors: The Wind Turbine Company (WTC)

Contract Amount: \$950,000.00

Match Funding: \$6,935,733

US Department of Energy (DOE) \$4,463,226

Wind Turbine Company: \$2,472,505

Contractor Project Manager: Robert Poore
(206) 292-0070

Commission Contract Manager: Dora Yen
(916) 653-4128

Project Description: The purpose of this project is to design, develop and demonstrate a utility scale wind turbine that will produce electricity at prices that do not need subsidies or premiums to compete in the emerging electricity marketplace. Rated at 350 kilowatts, this turbine is a horizontal axis, 2-blade, downwind turbine that brings together a number of concepts previously employed in other turbines of this design. In addition, this turbine is the first 2-blade downwind configured wind turbine to be developed in over 15 years, and is believed to be the first turbine to be completely designed employing newly available computer analytic codes that model wind turbine behavior and performance. By designing the turbine as a complete system, WTC is able to substantially improve turbine performance while significantly reducing weight compared with conventional wind turbines. Reducing weight lowers manufacturing costs which, together with improved performance leads directly to lower cost electricity. This machine will be well suited for both grid-connected, wind farm applications and for stand alone applications in combination with other generating and/or energy storage technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by increasing the likelihood that wind energy will not only remain a viable source of renewable electricity, but will actually supply a growing share of the electricity consumed in the state;
- Improving the energy cost/value of California's electricity by developing a wind turbine capable of producing electricity at prices competitive with the lowest cost sources of conventional electricity generation, currently recognized to be natural gas-fired combined-cycle combustion turbines;
- Improving the environmental and public health costs/risks of California's electricity by reducing air pollution and eliminating emissions that are believed to cause global warming; and
- Improving the safety of California's electricity by employing a unique tubular tower design of sufficient diameter to provide an internal passage from the ground to the tower top (nacelle).

Proposed Outcomes:

- Bringing to market readiness a utility scale wind turbine that is cost competitive with other sources of energy generation.
- Developing and field testing of a proof of concept wind turbine intended to demonstrate the feasibility of concepts and systems employed in the wind turbine, and to validate the computer codes used in design the turbine through testing.
- Developing of a prototype turbine that is intended to be a commercially saleable machine.
- Producing a commercial product that provides renewable, clean, reliable and cost competitive energy.
- Reduce capital costs due to weight reductions in key turbine components.
- Produce electricity for 3.5 cents/kWh or less when installed in annual quantities of 100 units or more in wind farms featuring wind resources at 15 mph.

Project Status: Project is on schedule and within budget. Currently the proof of concept wind turbine is operational and generating electricity at the National Renewable Energy Laboratory (NREL) test site. A commercial prototype model is being designed and targeted for installation at a Los Angeles test site in California in late June 2001. The project is expected to achieve the proposed outcomes.

DEVELOPMENT OF AN EXTENDED INDUCTION LOGGING TOOL FOR GEOTHERMAL EXPLORATION AND FIELD DEVELOPMENT

Contract #: 500-97-034

Contractor and Major Subcontractors: ElectroMagnetic Instruments, Inc. and Lawrence Livermore National Laboratory

Contract Amount: \$565,735

Match Funding: \$814,964

Contractor Project Manager: Michael Wilt, Ph.D.
(510) 232-7997

Commission Contract Manager: Gail Wiggett, Ph.D.,
(916) 653 –7551

Project Description: The purpose of this project is to design, manufacture and field test an extended induction logging device for geothermal applications in California. During the 2.5 year project, hardware and software for a high temperature and pressure tolerant logging tool will be developed and tested in several field trials in California and eventually internationally.

This device will provide a three dimensional image of the formation resistivity in the vicinity of a geothermal borehole. It can identify electricity conductive regions associated with high temperature fluids and map through-going fractures, which play a crucial role in fluid production.

The decline of power generation at the Geysers from a peak capacity of 1,600 MW to current production of less than 800 MW emphasizes the need for improved reservoir management. This phenomenon is a result of 1) a poor understanding of the fracture system that controls production, recharge and the movement of injected fluids, 2) insufficient recharge from all water sources, and 3) over-production and/or less than optimal injection.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing a tool that can determine fracture orientation and map formation resistivity that can lead to better understanding systems fracture, thus, improving reservoir management by optimizing field production and coordinating recharge;
- Improving the energy cost/value of California's electricity by including the establishment of new logging services and the enhancement of geothermal energy exploration; and
- Improving the environmental and public health costs/risks of California's electricity by developing an environmentally benign renewable energy source.

Proposed Outcomes:

- Provide for the design and construction of instrumentation that will provide technological solutions to several important problems in geothermal exploration and field development.
- Provide improved reservoir definition and fracture mapping in geothermal boreholes. This will better define drilling targets and reduce the number of boreholes required to produce adequate steam for power generation.

Project Status: The project is within budget, but slightly

behind schedule. The delay was caused by unexpected coupling problems with the GeoBILT instrument's transmitter and receiver modules. EMI staff concluded that the stray coupling was largely a capacitive effect from the antenna. The problem has been solved, software is ready, and field testing at the Lost Hills oil field in California is scheduled for this month (March 2001). Field tests under geothermal conditions are scheduled for May and July 2001.

DESIGN AND OPTIMIZATION OF A SOLAR-FIRED DOUBLE-EFFECT ABSORPTION CHILLER

Contract #: 500-97-035

Contractor and Major Subcontractors: Bergquam Energy Systems and Richard Christensen, Ohio State University; Sun Utility Network; Thermal Energy Systems Specialists; Instructional Systems.

Contract Amount: \$150,000

Match Funding: \$150,000

Contractor Project Manager: Dr. Jim Bergquam
(916) 383-9425

Commission Contract Manager: Prab S. Sethi, P.E.
(916) 654-4509

Project Description: This purpose of this project is to optimize the performance of a solar-fired double-effect absorption chiller, which can be used for space cooling of small to medium-sized commercial buildings. In addition, the project will modify and test the solar-fired chiller to determine generator configuration and operating conditions that maximize chiller and system performance.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing electrical consumption during peak demand created by cooling commercial buildings;
- Improving the energy cost/value of California's electricity by replacing packaged, compressor-based air conditioning systems with a lower-cost solar absorption system; and
- Improving the environment and public health of California's electricity by replacing CFCs in compression air conditioners with environmentally safe lithium bromide and water as the working fluid in a solar-driven absorption chiller.

Proposed Outcomes:

- A high-efficiency, double-effect absorption chiller that is optimized for coefficient of performance (COP), cooling capacity and operating temperature. The chiller will be driven by solar collectors. The chiller will have a coefficient-of-performance (COP) in the range of 1.2 to

1.4, when the first stage generator is operated at high temperature (approximately 300 degrees F). The chiller will have a COP in the range of 1.1 to 1.2, when the first stage generator is operated at low temperature (below 250 degrees F).

Project Status: Thermodynamic computer models of first stage generator have been designed and updated to predict and evaluate performance of the solar-fired double effect absorption chiller. The testing to determine the heat transfer co-efficient of generator tubes has been completed. Work is continuing for chiller modification. The project is on schedule and within budget.

POWERWHEEL DEMONSTRATION PROJECT

Contract #: 500-97-037

Contractor and Major Subcontractors: Power Wheel Associates and Ideal Electric Co.; Electrical Maintenance Consultants; Granger Engineering Services; N. J. Mccutchen, Inc.; ERC, Inc.; California State University, California Polytechnic Institute, San Luis Obispo; Johnson's Building Inspection Service

Contract Amount: \$200,000

Match Funding: \$200,000

Contractor Project Manager: Kenneth Broome
(650) 529-1810

Commission Contract Manager: Shahid Chaudhry
(916) 654-4858

Project Description: This purpose of this project is to prove the technical, economic, and environmental suitability of the PowerWheel technology for converting energy from low-head waterfalls into cost-competitive electricity. A 75 kW PowerWheel will be demonstrated in an irrigation canal and the electricity generated by it will be distributed to nearby agricultural, industrial, commercial, and residential customers through an interconnection with the electricity grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity as it is expected that electricity from this source will be more reliable than wind and solar energy;
- Improving the energy cost/value of California's electricity by providing electricity at a lower cost than conventional hydroelectricity costs; and
- Improving the environmental and public health costs/risks of California's electricity by displacement of electricity generated by combustion processes resulting in the reduction of exhaust gases of about 250 tons/kW/year of PowerWheel installations. In addition, PowerWheel installations will have no adverse impacts on water quality

and may enhance the dissolved oxygen content of the water.

Proposed Outcome:

- Prove the full-scale technical, economic, and environmental suitability of PowerWheel technology for conversion of the presently wasted renewable energy available in very low-head waterfalls into electricity.

Project Status: The project is behind schedule because the contractor must find another host site for the PowerWheel demonstration. One PowerWheel unit is ready for installation and demonstration. Because of poor cost analysis for the manufacturing of one demonstration unit, and design revisions, the manufacturing cost of the demonstration unit was significantly higher than initially estimated. Consequently, the tasks budget had to be reallocated. The Contractor will provide the additional in-kind services to meet the increased cost of the project. It is expected that this contract will achieve the proposed outcome.

NATURAL GAS COFIRING IN BIOMASS BOILERS

Contract #: 500-97-040

Contractor and Major Subcontractors: Gas Research Institute (GRI) and ARCADIS Geraghty & Miller; Coen Company; Burney Mountain Power; Fairhaven Power Company

Contract Amount: \$655,702

Match Funding: \$732,736

Contractor Project Manager: John Pratapas
(847) 768-0820

Commission Contract Manager: Prab S. Sethi, P.E.
(916) 654-4509

Project Description: The purpose of this project is to develop and retrofit low NO_x gas cofire technology on two biomass fired industrial power boilers at Burney Mountain Power and Fairhaven Power. With biomass, the high fuel moisture level and high fuel quality variability reduce electric competitiveness and increase environmental compliance costs. By firing small amounts of gas, approximately 10 percent of total heat input, operators can control the combustion process and avoid the usual problems that accompany combustion of wet biomass. Cofire offers an independently controlled combustion zone with higher temperatures, resulting in faster load response, better CO and opacity burnout, reduces carbon in the ash, and faster, cleaner startup. These benefits are essential for biomass to compete in the volatile deregulated power market that requires greater responsiveness than is now possible.

In this project, GRI will subcontract the low NO_x burner development to the cofire burner developer, Coen. The low NO_x burner will retain the high-pressure drop feature used earlier, but employs segmented gas/air zones and possibly inspired combustion gas dilution. The prototype burner will be installed in two northern California biomass power plants: Burney Mountain Power and Fairhaven Power. At Burney, cofire will allow recovery of lost derate and allow peak revenue load dispatch to effectively meet changing power demand. At Fairhaven, cofire will recover lost derate and allow compliance with CO and NO_x regulations.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing a method for improving the economics of grid-connected, distributed electricity generating biomass facilities;
- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts from biomass combustion by cofiring biomass with natural gas within an independently controlled combustion zone with high-temperature, turbulent mixing. The low NO_x feature is unique to California, and this demonstration should facilitate cofire permitting at other biomass facilities; and
- Impacting local and state economies by preserving employment opportunities in rural areas where these biomass facilities are typically located.

Proposed Technical Outcomes:

- Develop a low NO_x cofire burner for application to biomass fueled boilers.
- Apply the low NO_x cofire burner to increase the load following capability and turndown for Burney Mountain Power.
- Apply the low NO_x cofire burner to reduce CO emissions and recover lost derate with wet wood at Fairhaven Power.

Proposed Economic/cost Outcomes:

- Apply cofiring at Burney Mountain Power to capture high revenue power peaks and avoid low revenue periods to allow operation in the deregulated power market and reduce the break-even power price.
- Apply cofiring at Fairhaven Power to recover lost derate with wet wood and accrue incremental power sales revenue over the differential fuel price.

Project Status: The contract between GRI and the State of California was signed December 29, 1998. Contracts with the principal subcontractors - ARCADIS Geraghty & Miller, and Coen - have been signed.

Burner system installation on the 10 MW-boiler at Burney Mountain Power plant in Burney, California was completed in March 2000. The system has not been operated awaiting installation of the new, gas pipeline from the Pacific Gas & Electric (PG&E) main transmission line to the boiler. The work has not been completed because certain legal easements are being negotiated. System testing is expected to occur from June 2001.

Modifications are required to reduce NO_x emissions and performance optimization at Fairhaven Power plant in Eureka, California. These changes can be incorporated when the plant has a scheduled outage. Fairhaven continues to experience high plant generation demand. System testing is expected to be performed during April 2001.

COLLINS PINE COGENERATION PROJECT

Contract #: 500-98-043

Contractor and Major Subcontractors: Collins Pine Company and BC International (BCI); National Renewable Energy Laboratory (NREL); Plumas Corporation; Kemestrie; TSS Consultants; ProForma Systems, Inc.; Tembec Inc.; Raphael Katzen Associates International Inc.; CIFAR

Contract Amount: \$1,148,961

Match Funding: \$375,274

Contractor Project Manager: Jack Siverstson
(503) 227-1219

Commission Contract Manager: Dr. Valentino Tiangco
and Dr. Zhiqin Zhang (916) 654-4664

Project Description: This purpose of this project is to determine the technical and economic feasibility of integrating a new biomass-to-ethanol facility with an existing biomass power plant, located in Chester, California. If feasible, these two facilities would be operated together and become customers for each other's products. The ethanol facility would produce lignin for sale to the biomass boiler, which it would use to generate electricity and steam. In addition, the biomass power plant would generate electricity and steam for sale to the ethanol facility. This project seeks to lower the biomass power plant's electricity-generating costs so that it can become more cost-competitive after subsidies for renewable energy power plants expire in 2004. The lignin fuel supply from the ethanol facility may help to lower the biomass power plant's costs of generating electricity. The ethanol facility would also generate income by producing and selling ethanol and other value added co-products to customers outside of

Chester. The project is Phase I of a four-phase effort. If the results of Phase 1 are technically and economically positive, then facility developers may proceed with subsequent phases to design, permit, finance, construct and operate the ethanol facility.

This project supports the PIER Program objective of:

- Improving system reliability and power quality of California's electricity by seeking a cost-effective way to operate a distributed generation power plant in a rural area, which is prone to electricity supply disruptions;
- Maximizing market/economy connection by providing positive impacts to a California local economies by the creation of new jobs and new tax revenues in a rural area.

Specific Technical Outcomes:

- Determine whether the ethanol facility can produce up to 20 million gallons per year of ethanol from softwood feedstock using BCI technologies;
- Determine whether lignin from the ethanol facility can partially displace the existing fuel of Collins Pine biomass power plant by 30 percent to 60 percent; and
- Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility

Specific Economic Outcomes:

- Reduce the cost of electricity production at the Collins Pine biomass power plant by at least 1.5 cents/kWh.
- Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility and has a value of at least \$2/pound

Project Status:

- The project kickoff meeting was held on June 14, 1999 at the University of California, Davis.
- TSS Consultants submitted a draft of feedstock supply report on November 2000.
- A Critical Progress Review meeting was conducted at CEC on December 2000 to review the progress of their work. Feedstock supply report, market assessment of co-products and preliminary results of lignin tests were discussed.
- The Collins Pine team deduced that the feedstock supply in Chester area is sustainable to meet the demand of the collocated ethanol plant in Chester biomass power plant.
- NREL reported the bench-scale testing results on lignin residue produced from a mix of 70 percent white fir and 30 percent of Ponderosa pine using two-stage dilute acid and simulated enzyme processes. NREL concluded that the lignin residues had higher heating value (HHV), low levels of alkali-containing ash combined with low chlorine levels than the raw mix woodchips. This reduced the likelihood for fouling and slagging in lignin residue combustion systems. During the critical meeting, CIFAR

reported that for NREL case, cost of enzyme was calculated at \$0.318/gal of ethanol. The target enzyme cost is \$0.07/gal of ethanol.

- Enerkem or Kemestrie submitted the market analysis of co-product. Enerkem presented the market analysis of "proanthocyanidins" a natural compound coming from bark of softwoods from Northern California. Information on cost and technology maturity for production of proanthocyanidins was not provided in the report.
- The remaining budget balance was 52 percent for the project by February 2001. Tasks on producing hydrolyzate and lignin residues at pilot-scale, validation tests on pretreatment at bench-scale and pilot-scale, and validation tests on SSCF at bench-scale have not been started. This delays the work for the following lignin residue pilot-scale combustion test.
- Significant amount of energy was required for size reduction, pretreatment (steam explosion), fermentation, and distillation processes during ethanol production. The energy and mass balances were not provided yet.

POWER THERM, A PHOTOVOLTAIC/THERMAL HYBRID COMMERCIAL ROOFING SYSTEM

Contract #: 500-97-046

Contractor and Major Sub-Contractors: Powerlight Corporation and Advanced Thermal Technologies, Inc.; Sealed Air Corp.; Kathabar Inc.; David Roodvoets

Contract Amount: \$542,362
\$781,354- DOE PV Bonus
\$271,007- Commercial project contributors

Match Funds: \$1,052,361

Contractor Project Manager: Tom Dinwoodie
(510) 540-0550

Commission Contract Manager: Arnold Ward
(916) 657-4630

Project Description: This purpose of this project is to test a commercial photovoltaic/rooftop solar energy collector system providing electric power and thermal energy from sunlight. The integration of a solar-thermal component with the Contractor's PowerGuard® photovoltaic system will create a hybrid photovoltaic/thermal (PV/T) system, called PowerTherm™. This technology is suitable for buildings with flat to moderately sloping roofs and will increase the economic value of PV roof-tile systems for commercial building owners by providing them with two ways to lower their energy utility costs: PV-electrical generation and solar hot-water production for on-site use.

The PowerGuard® product was substantially advanced under a product R&D contract with the Commission's Energy Technologies Advancement Program and has

been successfully tested in dozens of applications internationally. PowerGuard® incorporates state-of-the-art PV technology with extruded foam backing into roofing tiles. These tiles, or panels, are electrically connected to an inverter that feeds quality AC Power to the building's electrical system at or near peak load demand periods for electricity suppliers. This technology can be integrated into new and re-roofing projects, or readily applied over existing roofs.

This project contributes to the PIER program objective of:

- Improving the reliability/quality of California's electricity system by developing a distributed-energy technology; and
- Improving environmental and public health cost/risks of California's electric system by deploying a renewable energy source that does not emit nitrous oxides, sulfur oxides, and carbon dioxide when generating electricity.

Proposed Outcomes:

- Introduce a cost-effective PowerTherm™ product to commercial and residential building owners.
- Improve heat transfer between the PV laminate and solar-thermal absorber by 40 percent (from .5 to .7 BTU/hour per foot per degrees F.).
- Increase the effective irradiance of the sloped collector by 5 percent.
- Increase the thermal performance of the overall system by 35 percent.
- Improve the overall system efficiency by 45 percent.
- Achieve a net (thermal-only) system production tile cost of \$6 per square foot.
- Achieve a thermal component payback of less than 5 years in specified markets.

Project Status: This project is on schedule and within budget.

RESIDENTIAL ELECTRIC POWER SECURITY

Contract #: 500-97-047

Contractor and Major Subcontractor: Utility Power Group (UPG) and Southwest Technology Development Institute; and New Mexico State University

Contract Amount: \$426,343

Match Funding: \$994,799

Contractor Project Manager: Michael Stern
(818) 700-1995

Commission Contract Manager: Arnold Ward
(916) 657-4630

Project Description: The purpose of this project is to design, assemble, and test a photovoltaic (PV) power

system for residential rooftop applications. The project will focus on three aspects of the system. In the first part, UPG will design, assemble, and test a novel rooftop PV panel attachment and interconnection process. The second part will produce a fully integrated multifunctional dc-ac/ac-dc power collection, conversion, and control unit. A third focus will be an optional low-cost battery unit designed to plug into the Power Unit to provide a dependable supply of energy for critical household loads.

The proposed PV power system will possess features such as low cost, high efficiency, adaptable to a wide range of roof tops, high power quality, and compliance with all NEC, UL, IEEE, and Utility Interconnection Codes and Standards. The developed system is expected to reduce the installed cost of grid connected PV by approximately 34 percent, and improve their reliability by a factor of five.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by increasing reliability over current systems from 10 percent rate of failure to 2 percent rate of failure (a five fold improvement); and
- Improving the energy cost/value of California's electricity by optimizing design of residential roof-mounted PV through a system integration approach, increase system modularity to reduce manufacturing costs, and develop standardized hardware and methods for PV/roof attachment to reduce installation costs.

Proposed Outcome:

- Develop an advanced version of the multi-functional rooftop PV power processing system with a number of market driven advanced capabilities which do not exist in any commercially available power processing product. Contractor anticipates reducing materials and installation costs (exclusive of the PV module) by 30 percent.

Project Status: The anticipated completion date of all deliverables has been extended to August 1, 2001.

Accomplishments to date:

- Design revisions of the PV array.
- Submission of PV Array for UL review.
- Installation of a production version of the PV Array.
- Submission of Power Unit CAM files of revised printed circuit boards to vendors.
- Design revisions of Power Unit electro-mechanical system.
- Submission of Power Unit for UL review
- Design revisions of Energy Storage Unit.
- Submission of Energy Storage Unit for UL review.
- Testing of Energy Storage Unit.
- UL testing of Energy Storage Unit.

HYBRID SOLAR-FOSSIL THERMOPHOTOVOLTAICS

Contract #: 500-97-048

Contractor and Major Subcontractors: EDTEK and Brookhaven National Laboratory; Power Management Systems, Inc.; The Charters Group, Inc.; NML Partnership; Pacific Financial Group

Contract Amount: \$867,945

Match Funding: \$1,917,107

Contractor Project Manager: W. Ed Horne
(253) 395-8084

Commission Contract Manager: Prab S. Sethi, P.E.
(916) 654-4509

Project Description: The purpose of this project is for EDTEK, Inc. to design, fabricate and test a modular, hybrid solar/fossil-fueled thermophotovoltaic (SFTPV) system that can produce electricity and process grade hot water 24 hours per day with a recovery efficiency of about 83 percent. In this system, highly concentrated sunlight is directed into a cavity where the surrounding walls are heated to incandescence, the state where visible light is emitted from a hot object. A natural gas flame is also directed into the cavity to heat its walls and excite the PV cells, as does the concentrated sunlight.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing a new distributed generation technology; and
- Improving the environmental and public health costs/risks of California's electricity through partial use of solar energy, a renewable and non-polluting energy source.

Proposed Outcomes: Develop, manufacture and demonstrate a pre-production hybrid prototype SFTPV cogeneration power system that can produce economically competitive electric power and thermal energy on a 24-hour basis. The SFTPV power system will convert sunlight to electricity with 25 percent overall efficiency, and natural gas to electricity at an overall efficiency of 20 percent while producing process grade hot water at a recovery efficiency of 83 percent.

Project Status: The project term is to March 31, 2002. The contractor has been working with Cornell University, University of Houston, and NREL to use ion beam lithography process and e-beam lithography to prepare stencils for the pre-filters. A test unit prefilter is under fabrication for testing at NREL. The GaSb PV cells have been assembled into arrays for the test unit and final interconnections are being applied. The prisms have been fabricated and are waiting for reflecting coating to be deposited. A dish mounting and tracking system has been designed. A test of hydraulic tacking mechanism has been

successfully completed. The project is on schedule and within budget.

POWERGUARD® PV SYSTEM ADVANCED MANUFACTURING DEVELOPMENT AND SCALE-UP

Contract #: 500-97-049

Contractor and Major SubContractors: PowerLight Corporation and Pulse Energy Systems; Trace Technologies; Colorado State University; Augustyn and Company; T. Clear Engineering; Feldman, Waldman and Klein; Solarex; Ananda Power Technologies
Sandia National Labs

Contract Amount: \$958,991
\$998,977 NREL
\$ 50,000 Trace Engineering
\$532,734 New York State
Power Authority
\$412,710 Various commercial
project contributors

Match Funds Amounts: \$1,994,421

Contractor Project Manager: Tom Dinwoodie
(510) 540-0550

Commission Contract Manager: Arnold Ward
(916) 657-4630

Project Description: The purpose of this project is to expand grid-connected markets for PowerGuard® systems by reducing component and system manufacturing costs, enhancing system reliability, and obtaining specific certifications. PowerGuard® is a roof-top photovoltaic (PV) system providing electrical power. Furthermore, this project will establish a new California manufacturing facility, using the automated and semi-automated fabrication innovations developed under this contract.

This project supports the PIER Program objectives of:

- Improving the reliability of California's electricity system by developing a renewable, distributed-energy technology;
- Improving the environmental and public health costs/risks of California's electricity by deploying a renewable energy source which does not emit NO_x (nitrous oxides), SO_x (sulfur oxides), and CO₂ (carbon dioxide) when generating electricity; and
- Positively impacting California's economy by creating new manufacturing jobs.

Proposed Outcomes:

- Reduce PowerGuard® system costs and improve system reliability through advanced fabrication equipment, which will automate or semi-automate system component manufacturing, thereby increasing production capacity and reducing labor costs.

- Develop PowerLight's in-house capability to fabricate PowerCurb housings
(Powercurb is the array perimeter securement of the PV panels and contains and secures the outer perimeter of the PV panels to the roof. Powercurbs are used in retrofit applications over an existing roof).
- Ensure that PowerGuard® systems, as modified under this contract, will continue to receive certifications from specific independent testing and certification entities.
- Reduce PowerGuard PV roof top system costs to create cost-effective PV systems, which will not need subsidies after 2002.
- By semi- or fully automating many aspects of PowerGuard® system manufacturing, reduce unit costs to \$3.05 per peak watt (Wp).
- Reduce the cost of the PowerGuard® RT PowerCurb to \$4 per linear foot.
- Increase Component Reliability Objectives.
- Meet performance criteria for the Trace Technology's grid-tied inverter control board with a calculated Mean Time Between Failures of 59,000 or greater.
- Construct a 5,000 square foot or greater "Cell-to-System" manufacturing facility in California which includes an automated PowerGuard® Tile Fabrication line, that is capable of yielding 400 tile substrates per day throughput.
- Assure that PowerGuard® manufacturing meets all applicable NEPA, OSHA and building code requirements.
- Establish allowable building heights for PowerGuard® system installations.
- Obtain Underwriters Laboratory (UL), International Conference of Building Officials (ICBO), and international certifications for PowerGuard® systems.

Project Status: This project is on schedule and within budget.

UTILIZATION OF WASTE RENEWABLE FUELS IN BOILERS WITH MINIMIZATION OF POLLUTANT EMISSIONS

Contract #: 500-98-037

Contractor and Major Subcontractor: GE Energy and Environmental Research Corporation; University of California, Davis; T.R. Miles Consultants; Stanford University

Contract Amount: \$981,952

Match Funding: \$610,238

Contractor Project Manager: Dr. Goerge Rizeq (949) 859-8851

Commission Contract Manager: Prab S. Sethi, P.E. (916) 654-4509

Project Description: The purpose of this project is to develop an innovative technology, Close-Coupled

Gasification (CCG), which is a synergistic combination of direct combustion, biomass/waste gasification, and GE/EER's emission control approaches to be applied in existing California biomass boilers. The CCG technology focuses on bringing renewable energy, energy supply reliability, energy price stability, and protection of the environment to the California marketplace. The CCG technology will also help to solve the existing problems of the biomass power industry in California. The continued survival of the biomass power industry greatly depends on the expansion of availability of diverse, low-cost fuel sources, and this project develops specific feedstocks to be used in combined combustion/gasification mode.

The goal of this project is to develop a preliminary conceptual design for a full-scale demonstration facility of CCG technology. The design would retrofit (couple) CCG technology in a California biomass power plant to reduce NO_x emissions by using gasified, low-grade biomass/waste fuel. This project is Phase I of a four-phase CCG technology commercialization plan. If analyses prove that the project would be technically and economically feasible, the project developers may decide to design, retrofit and operate the demonstration facility (Phases II and III) and to commercialize the technology throughout California and elsewhere (Phase IV).

This project supports the PIER Program objectives of:

- Improving the environmental and public health risks/costs of California's electricity by developing a lower-cost method for existing, biomass power plants to control NO_x and other pollutant emissions.
- Maximizing market connection for the project's research results. Specifically, three California biomass power plants, which are potential partners in the full-scale CCG technology demonstration, will participate in this project's design and economic studies to determine if the technology will provide economic and operational benefits to their units.

Proposed Outcomes:

Specific technical outcomes:

- Design and development of an economic process (demonstration facility), which is capable of converting biomass/waste into gaseous fuel to be used as supplementary cofiring/reburning fuel and NO_x control in California biomass boilers.
- Produce 10-30 percent of gaseous fuel (by heat input) for a 25 MW biomass boiler;
- Reduce NO_x emissions up to 65 percent in basic reburning and 90 percent in advanced reburning (AR); and complying with all other California emissions standards.

Specific economic outcome:

- Reduce NO_x control costs by at least 20 percent, compared to the costs of existing NO_x control methods used by biomass boilers owned by Wheelabrator Shasta/Hudson Energy Company, Woodland Biomass, and Wadham Energy.

Project Status: The project kick-off meeting was held at the Marriott Hotel in Oakland, CA, during the Fourth Biomass Conference of the Americas on August 30, 1999.

Task 2.1 (Assessment of California Waste and Biomass Resources for Gasification): Work was initiated by conducting an initial search for information on waste fuel types, amount, composition, availability, and cost. The search encompassed review of various biomass Internet sites, including Western Regional Biomass Energy Program, DOE, NREL (Biomass Resource Informational Clearinghouse), and Oak Ridge National Lab. Additional work on Task 2.1 was done, including compiling literature studies for various waste streams, and contacting industry trade groups and suppliers to evaluate current waste availability, handling practices and costs.

Task 2.2 (Laboratory Scale Gasification Screening Experiments): Work to be conducted at the University of California – Davis, was initiated. This included preparing the kick-off meeting presentation focussing on research task approach, laboratory equipment, experience and capabilities. Additionally, the UC Davis group started preparations for the fluidized bed reactor to be used in Task 2.2. Work is continuing for experimental analysis of tar and alkali concentrations, along with mass and energy balances.

Task 2.3 (Kinetics of Biomass and Waste Particles Gasification/ Reburning): Preliminary preparations were conducted by the Stanford University group. This included preparing the kick-off meeting presentation (Titled: *Characterizations of the Behaviors of the Chars of Biomass and Waste-Derived Fuels under Reburning Conditions*) which explained the approach planned for performing the research task. This included explaining the theory and presenting the facilities at Stanford University. Preparatory laboratory work was also conducted including testing and repairing equipment where necessary, and in some instances, improving upon some equipment for the Commission project. Additionally, some tests have been performed on various synthetic chars to validate the "Mode of Char Particle Burning Model" intended to be utilized in the Commission project.

Task 2.4/2.5 Pilot Scale Co-firing/reburning Stoker Simulation Tests with multiple biomass fuels: The preparation and preliminary shakedown tests were conducted for the pilot facilities consisting of biomass feeding system, the fluidized bed gasifier, and the stoker boiler simulator. The outcome of shakedown testing is being reviewed. The project is on schedule and within budget.

COFUND 59, CALIFORNIA WIND ENERGY FORECASTING SYSTEM DEVELOPMENT AND TESTING

Contract #: 100-98-001

Contractor and Major Sub-Contractors: Weather Service International, Risoe National Laboratory (Denmark), TrueWind Solutions, University of California, Davis

CEC Project Amount: 1999: \$64,020
2000: \$441,324
Total: \$508,344

Match Funding: \$0

Contractor Project Manager: Chuck McGowin

Commission Project Manager: Dora Yen

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to develop and commercialize a California Wind Energy Forecasting System to generate two or more daily forecasts of the hourly wind power generation expected over the next 48 hours for each of the wind generation areas in the state. Improved wind forecasting allows system operators and planners to better anticipate both the short- and long-term availability of wind power. The resulting forecasts will be used by the owners and operators of the various wind power facilities, California electric utilities, and the California ISO, PX, and APX.

This project contributes to the PIER program objectives of:

- Improving energy cost/value by enhancing the performance and value of renewable wind energy.
- Improving the environment by enhancing wind power's attractiveness as a generation alternative to less environmentally friendly options.

The goal of this project is to develop and conduct a brief wind forecasting test at a single site. Results of that test will inform development and testing of three parallel wind forecasting systems at four test sites: Solano County, Altamont Pass, Tehachapi Pass, and San Geronio Pass. Wind energy forecasts for the four wind plants will then be scaled up to generate regional and total state forecasts. The project will next develop an alternate wind plant power curve at one California site based on wind-tunnel testing

conducted at U.C. Davis, followed by selection of a developer to commercialize the system.

Proposed Outcomes:

1. Select one California wind plant site for preliminary testing, develop and operate a wind forecasting system, evaluate its performance, and refine the system.
2. Conduct parallel one-year tests of three wind energy forecasting systems developed by Weather Service International, Risoe National Laboratory, and TrueWind Solutions at four California sites. Operate systems, collect and evaluate performance data, and refine systems. Present the results in a final report.
3. Based on site and wind turbine data, develop a scale topographic model of a test site and conduct wind tunnel testing to assess the impact of wind turbine power curve for each wind turbine at the site to predict wind generation as a function of wind speed and direction.

4. Evaluate the wind energy forecasting system performance based on results of earlier trials.
5. Complete a competitive solicitation for continued development and operation of a commercial wind forecasting system.
6. Complete and commercialize the resulting California Wind Energy Forecasting System. Operate the system, evaluate its performance, and refine the system.

Project Status: Start of work will be delayed until early 2001. In December 2000, EPRI published a status report on the project entitled *California Wind Energy Forecasting Program Description and Status – 2000*.

Environmentally-Preferred Advanced Generation

SOLID-OXIDE FUEL CELL/MICRO TURBINE GENERATION HYBRID

Contract #: 500-97-012-07

Contractor and Major Subcontractors: Edison Technology Solutions and Siemens-Westinghouse / Northern Research Engineering Corporation (NERC); University of California, Irvine (UCI); Energy Systems Services Corporation; Paragon

Contract Amount: \$2,000,000

Match Funding: \$14,900,000

Contractor Project Manager: John Leeper
(626) 815-0512

Commission Contract Manager: Art Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this project is to demonstrate proof-of-concept testing for integrating two dissimilar electricity producing distributed generation technologies – pressurized solid oxide fuel cell (PSOFC) and micro turbine generator (MTG) – into a 250kW hybrid unit. This project will support Edison Technology Solutions' (ETS) participation in a \$16.9 million public/private sector collaborative project with the U.S. DOE, Siemens Westinghouse and the University of California, Irvine (UCI), where the technology will be demonstrated. This project will demonstrate a "first of a kind integration" of both technologies. While both technologies are separately nearing commercialization, their integration into a hybrid unit is expected to offer significant environmental and energy efficiency benefits. Further, it is expected that the mature, commercial hybrid units will be more competitive than stand-alone fuel cells and will provide the same level of clean power output. Successful completion and utilization of this technology will result in air quality benefits through a reduction in NO_x and greenhouse gas emissions. The integrated pressurized fuel cell and MTG hybrid will result in a 60 percent electrical efficiency-generating device that is equal to or greater than any other form of fossil-energy generation.

This project supports the PIER Program objective of:

- Improving the energy cost/value and improving environmental and public health costs/risk of California's electricity by providing reliable, diverse, energy-efficient, low-emission distributed electrical resources.

Proposed Outcomes:

- Develop, test and demonstrate a Solid-Oxide Fuel Cell/Micro Turbine Generation Hybrid distributed power generation technology.

Project Status: Development of solid oxide fuel cell stack and micro-turbine was delayed due to developmental problems. The contract term was been extended until June 30, 2001.

LOW NO_x GAS TURBINE COMBUSTORS FOR DISTRIBUTED POWER GENERATION

Contract #: 500-97-031

Contractor: Alzeta Corporation

Contract Amount: \$878,788

Match Funding: \$675,000

Contractor Project Manager: Dr. Scott Smith
(408) 727-8282

Commission Contract Manager: Dave Hatfield, P.E.
(916) 654-7119

Project Description: The purpose of this project is to continue development of the Gas Turbine Semi-Radiant Burner (GTSB) for gas turbine applications. The outcome product for this project is an integrated design incorporating the core GTSB technology with the control and hardware interfaces necessary for application to one or more commercially available gas turbine engines.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by reducing the cost for NO_x mitigation and reduction technology for small- and micro-scale gas turbines; and
- Reducing environmental and public health costs/risk of electricity generation in California by achieving greater emissions reductions than currently required by law.

Proposed Outcomes:

- Simultaneous reduction of NO_x and CO emission to less than 2 ppm (15 percent O₂) without any post combustion exhaust clean up.
- Expected cost on par with original equipment combustors.
- Eliminate the need for Selective Catalytic Reduction (SCR) on gas turbines in non-attainment areas.

Project Status: The project is on schedule and within budget.

DURABILITY OF CATALYTIC COMBUSTION SYSTEMS

Contract #: 500-97-033

Contractor: Catalytica Combustion Systems, Incorporated

Contract Amount: \$1,316,303

Match Funding: \$3,029,846

Contractor Project Manager: Tom Morjig (650) 940-6371

Commission Contract Manager: Avtar Bining, Ph.D.
(916) 657-2002

Project Description: The purpose of this project is to conduct the research and development necessary to advance catalytic combustion technology for on-engine field testing in a 1.5 MW Kawasaki (KHI) gas turbine engine. The technology must have demonstrated high durability and reliability for fast market acceptance. To accomplish this goal, Catalytica will operate the currently developed Kawasaki combustor in a power generation facility for 8000 hours (1 year). In addition, Catalytica will continue the rapid development of the technologies required to obtain the necessary durability and reliability for the KHI combustor and catalyst module. Once reliability has been demonstrated, the Kawasaki combustor will be moved to commercial sites for field-testing. Finally, the Kawasaki combustor will be offered as a commercial product and begin translation of the technology to other gas turbine engines. The project goal is to improve energy cost and value of California's electricity market by creating a cost-competitive alternative to conventional NO_x mitigation and reduction technologies for gas turbines in all size ranges.

This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by eliminating harmful pollutants and allowing gas turbines, which offer higher reliability compared to the current generating fleet, to compete in a deregulated market;
- Improving the energy cost/value of California's electricity by introducing catalytically-fired, industrial scale gas turbines that will decrease the cost of electricity compared to the higher cost option of these gas turbines equipped with post-combustion treatment systems such as selective catalytic reduction; and
- Improving the environment and public health risks of California's electricity by incorporating a pollution prevention rather than a pollution clean-up technology that is potentially more effective at reducing NO_x and CO emissions by eliminating them from formation during combustion.

Proposed Outcomes:

- Bring to market readiness a catalytic combustion system that is cost competitive with other commercially available

NO_x reduction technologies for industrial-scale gas turbines.

- Lab test the catalytic combustion system under actual engine service conditions to validate the adequacy of all components of the design and to establish durability during an 8000-hour performance test.
- Computation fluid dynamics (CFD) studies of the fuel-air mixer system that will improve the design by improving performance and reducing cost for the final commercial engine.
- Lab test to determine the effect of variability in gas fuel composition on catalyst performance.
- Produce a commercial product that provides cost effective NO_x control that meets permitting requirements in the most restrictive air quality districts. The catalytic combustion system resulting from this project will have a lower capital than selective catalytic combustion systems for the engines with comparable NO_x control.

Project Status: The project is on schedule, within budget, and is expected to achieve proposed outcomes.

A NOVEL STEAM REFORMING REACTOR FOR FUEL CELL DISTRIBUTED POWER GENERATION

Contract #: 500-97-038

Contractor and Major Subcontractor: Energy and Environmental Research (EER) and Phillips Petroleum Company

Contract Amount: \$349,852

Match Funding: \$303,457

Contractor Project Manager: Jerald Cole (949) 859-8851

Commission Contract Manager: Art Soinski Ph.D.
(916) 654-4674

Project Description: The goal of this project is to advance the technology of distributed power generation using fuel cells by developing a novel steam reforming process to convert fossil fuels to hydrogen. The process promises to advance fuel cell technologies that are being hampered by the lack of hydrogen distribution and production systems. Specifically, under this project, EER will develop and evaluate extended life catalysts and sorbents and apply their discoveries to a refined reactor design for advancing the steam reforming process. The key technical issues to be addressed by this project are developing catalysts with extended lifetimes and optimizing the use of these catalysts in the process.

This project supports the PIER Program objective of:

- Improving the reliability/quality, improving the environmental and public health costs/risks and improving the energy cost/value of California's electricity by advancing the use of low-emission, low-cost, distributed resource fuel cell technologies.

Proposed Outcome:

- Develop and evaluate catalysts and sorbents and apply their discoveries to a refined reactor design for advancing the steam reforming process.
- Develop catalysts with extended lifetimes and optimizing the use of these catalysts in the process.
- Design and build a prototype-reforming unit. The proposed effort will fill in a missing link in a broader program currently underway with support from DOE.

Project Status: The project is behind schedule due to a discovery that some, potentially, more durable catalysts experienced secondary reactions that inhibited performance. The project is on budget, and the project is expected to achieve the proposed outcome.

75-KW MOLTEN-CARBONATE FUEL CELL (MCFC) STACK VERIFICATION TEST

Contract #: 500-97-039

Contractor and Major Subcontractors: M-C Power Corporation and San Diego Gas and Electric; Bechtel National, Inc.; Alternative Energy Systems Consultants; and Stewart and Stevensen

Contract Amount: \$1,000,000

Match Funding: \$1,956,841

Contractor Project Manager: Thomas Benjamin (630) 986-8040, Ext. 159

Commission Contract Manager: Art Soinski Ph.D. (916) 654-4674

Project Description: The purpose of this project is to demonstrate the energy-producing performance of advanced design molten carbonate fuel cell (MCFC) stack components in a 75 kW electric power generator. The 75 kW MCFC Stack Verification Test Project is an important step toward commercializing MCFC power generation technology in the year 2002. The test will be conducted at the existing test facility at Marine Corps Air Station Miramar in San Diego. Based on information from a prior Miramar test and small-scale factory tests, advances in fuel cell components and stack design have been identified. A new 75 kW stack will be built incorporating the advanced technology and will be installed at Miramar for testing. The test program participants include the U.S. Department of Energy, the California Energy Commission, San Diego Gas & Electric, and M-C Power, Incorporated.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by developing an efficient electric generating technology that emits negligible levels of ozone and smog precursor pollutants and reduced levels of carbon dioxide; and

- Improving the reliability/quality of California's electricity by demonstrating fuel cell technology for distributed generation applications.

Proposed Outcomes:

- Verify the long term current density performance of M-C Power's most advanced stack design in full size cells under field conditions.
- Evaluate the effect of anode recycle on generator performance.
- Gather operating data upon which to base the design of future commercial prototype generators.
- 50-80 percent higher efficiency than conventional combustion-type generators.
- Negligible emissions of ozone and smog precursor pollutants.
- Reduced production of carbon dioxide exceeding target of climate change initiatives.
- Higher reliability of service – high-quality power, few moving parts and no transmission lines; reduced consumption of fuel resources; and competitive cost of electricity.

Project Status:

- M-C Power, Inc. successfully completed nearly 5 months of testing of its integrated, pressurized molten carbonate fuel cell (MCFC) power plant technology.
- Testing took place at M-C Power's system verification test facility at the Marine Corps Air Station (MCAS) Miramar in San Diego, California. Performance operations of a new improved design 75 kW stack, associated systems and components were initiated on July 4, 1999 and continued until the end of November 1999.
- The MCFC power plant operated for about 3,300 hours and generated 250 MWh of electricity. The power system generation consistently exceeded the 75 kW rating throughout the test period.
- Nitrogen oxide emission levels were below 0.4 ppm, which verified significant environmental benefits of MCFC technology.
- System performance exceeded expectations and provided valuable design and operating information which is essential for the design of a commercial unit. The commercial unit will be ready for testing in 2001. This test demonstrated the viability of M-C Power's pressurized power plant concept. It is a major step forward toward the market introduction of MCFC power plants in 2002.

ENERGY EFFICIENT, LOW EMISSION, COST EFFECTIVE MICROPILOT IGNITED NATURAL GAS ENGINE DRIVEN GENSET FOR DEREGULATED, DISTRIBUTED POWER GENERATION MARKETS

Contract #: 500-97-041

Contractor and Major Subcontractor: Gas Research Institute, Chicago, IL and BKM, Inc., San Diego, CA

Contract Amount: \$982,528

Match Funding: \$250,000

Contractor Project Manager: Lou Lautman
(773) 399-8100

Commission Contract Manager: Avtar Bining, Ph.D.
(916) 657-2002

Project Description: The purpose of this project is to develop a new technology which takes advantage of the cost and emissions benefits of clean burning natural gas, the fuel efficiency of modern diesel engines, the low first cost of high production diesel engines, and the ease of installing distributed power with an internal combustion engine. This technology is known as MicroPilot diesel cycle natural gas engine.

This project supports the PIER Program objectives of improving of:

- Improving the reliability/quality of California's electricity by making lower cost, more reliable and better quality electrical power available via distributed generation where it is not possible to do so under central power generation approaches;
- Improving the energy cost/value of California's electricity by providing expected energy cost under \$0.04/kWhr and installed cost under \$200/kW; and
- Improving the environmental and public health costs/risks of California's electricity because there is no known or suspected adverse impacts to the environment, citizen's health or safety resulting from this project or the commercialization of this technology.

Proposed Outcome:

- Complete development of a 1- percent MicroPilot engine.
- Demonstrate a production ready version of the MicroPilot technology applied to the very popular Caterpillar 3412 diesel generator set engine. The MicroPilot technology developed and demonstrated under this project will be offered to Caterpillar (and all other OEM manufacturers) for commercialization.

Project Status: The project is late by about five months due to late delivery of one of the engines for use in this project. The discussion for reducing this delay is underway. The term of this contract expires on March 31, 2002. GRI, however, plan to complete this contract by December 31, 2000. The project is on budget and is expected to achieve the proposed outcome.

CATALYTIC COMBUSTOR-FIRED GAS TURBINE FOR DISTRIBUTED POWER AND COGENERATION APPLICATIONS

Contract #: 500-98-041

Contractor and Major Subcontractors: Solar Turbines, Incorporated and Catalytica Combustion Systems, Incorporated; University of California, Irvine

Contract Amount: \$814,543.00

Solar Turbines: \$427,700

Catalytica: \$345,691

Match Funding: \$773,391

Contractor Project Manager: Kenneth Smith, Ph.D.
(619) 544-5539

Commission Contract Manager: Avtar Bining, Ph.D.
(916) 657-2002

Project Description: The purpose of this project is to develop the necessary component technologies and complete engineering design of a multi-can catalytic combustion system suitable for application in two gas turbines, the Taurus 60, rated at 5.2 MW, and the Centaur 50, rated at 4.6 MW. The system will be designed for 5-ppm NO_x emissions without the use of water or steam injection or the use of any post-combustion NO_x reduction. This project is the first of three phases of development. Phase two will conduct hot testing of the combustor assembly. Phase three will test the combustor in actual operation on a gas turbine.

This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by eliminating harmful pollutants and allowing these gas turbines, which offer higher reliability compared to the current generating fleet, to compete in a deregulated market;
- Improving the energy cost/value of California's electricity by introducing catalytically fired industrial scale gas turbines that will decrease the cost of electricity compared to the higher-cost option of these gas turbines equipped with post-combustion treatment systems such as selective catalytic reduction (SCR); and
- Improving the environment and public health cost/risks of California's electricity by incorporating a pollution prevention rather than a pollution clean-up technology that is potentially more effective at reducing NO_x and CO emissions by eliminating them from formation during combustion.

Proposed Outcomes:

- Bring to market readiness, a catalytic combustion system that is cost competitive with other commercially available NO_x reduction technologies for industrial scale gas turbines.
- Lab test to develop and then integrate the optimum preburner, premixer, catalytic core and burn out zone liner designs into the Centaur 50 and Taurus 60 gas turbines.

- Implement a control system strategy for the catalytic combustion system capable of handling start-up, shutdown, load following, and full load loss without damage to the combustor or gas turbine.
- Produce a commercial product that provides cost effective NO_x control that meets permitting requirements in the most restrictive air quality districts.
- Capital cost over eighty percent less than selective catalytic combustion systems for the Taurus and Centaur gas turbines with comparable NO_x control. This will result from completion of this three-phase project.

Project Status: The project is on schedule, on budget, and is expected to achieve proposed outcomes.

TARGETS 63.0/23 EMERGING DISTRIBUTED RESOURCE TECHNOLOGIES; 63.1 IC ENGINE DEVELOPMENT FOR DR APPLICATIONS; 63.4 FUEL CELL DISTRIBUTED POWER SYSTEMS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Power Computing Systems; Proton Energy Systems; Hpower; American Fuel Cell Corporation; NYSEG; International Fuel Cell; TMI; MSRI; SCE; Chugach Electric Assoc.; SDG&E; American Electric Power

CEC Project Amount: 1999: \$249,250
2000: \$179,400
Total: \$428,650

Match Funding: 1999: \$3,796,885
2000: \$3,301,088
Total: \$7,097,973

Contractor Project Manager: Dan Rastler
(650) 855-2521

Commission Project Manager: Jairam Gopal
(916) 654-4880

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to promote the potential that distributed resources (DR) have to provide a substantial portion of the energy alternatives now demanded by California electricity users. Both energy service providers and customers need accurate and unbiased information on the benefits and liabilities associated with commercially available and emerging distributed resource technologies. DR technologies offer third-party energy service providers and energy customers innovative solutions to their energy service needs. EPRI's Emerging DR Technologies target provides detailed information on commercially mature reciprocating engines and gas turbines, and emerging microturbines and fuel cell systems technologies. To gather this information, EPRI

assesses advanced DR components, performs technology validations, and leads pre-commercial development on technologies that offer high pay-off. As a member, the Energy Commission will obtain intelligence in three distinct areas: rapid changes in technology, development of new distributed resources, and post-R&D commercialization initiatives. This target examines a balanced portfolio of near, intermediate, and long-term options.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power; and
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide unbiased accurate information on emerging DR technologies to increase customer choice and enable competition.
2. Provide DR technologies information and assistance toward the resolution of cross cutting issues that generally slow the adoption process.
3. Bring to market readiness fuel cell technologies that include polymer electrolyte membrane (PEM) fuel cell systems and ultra-high efficient solid-oxide fuel cells (SOFC).
4. Accelerate the development of spark-ignited and micro-pilot, dual-fuel natural gas engines with major engine manufacturers for commercial applications in the 600 kW to 2 MW size range.
5. Conduct a Tailored Collaboration entitled "Workshop on Environmental Impacts of New Generation in California" to inform the public debate on the environmental effects of new generation options.
6. Conduct a Tailored Collaboration entitled "Emissions Testing and Certification Guidelines for DG Generators" to reduce the time and cost for DG technologies to meet existing and future emissions regulations.

Actual Outcomes:

1. Unbiased accurate information.
 - Assessment of Distributed Resource Technologies was published.
 - Bench and field tests were conducted on PEM fuel cells and microturbines, and detailed technology

assessments—including data on performance, emissions, and power quality characteristics—were published.

- A state-of-the-art assessment was produced on internal combustion engines for electric generation applications.
 - A state-of-the-art assessment was produced on residential power systems and testing of a 3-kW PEM fuel cell.
 - A report was published on design and testing of a landfill gas cleanup system for carbonate fuel cell power plants.
 - A market study report was published on advanced turbines.
 - Intelligence Reports—quarterly reports on the latest breaking information on DR technologies—were published.
 - DR technologies were evaluated through site visits and meetings with leading manufacturers, and results were published in quarterly reports and technical reports.
 - An annual national DR conference was organized, providing a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
2. Resolution of cross-cutting issues.
- A report was published on the benefits and status of gas turbine recuperators.
 - A report was published on emission control technologies for DR options.
 - The performance of a 7-MW gas turbine for transmission and distribution grid support and a residential fuel cell were evaluated.
3. Fuel cell technologies.
- An advanced solid oxide fuel cell (SOFC) system was successfully tested. Test results were summarized in a report.
 - A technology assessment of residential power systems was published.
 - A report on PEM fuel cells as UPS and peakers was published.
 - An assessment was published of fuel-processing technology for fuel cells.
 - A 220-kW SOFC-microturbine hybrid system was tested, and results published.
 - A report evaluating 100-kW to 300-kW SOFC systems was published.
 - A 600-watt UPS system based on PEM stacks was developed and tested. A report was published.
 - A bottom-up assessment of planar SOFC technologies was conducted, investigating the details of the cell, stack, subsystem, and balance-of-plant. A report summarized results.
 - A report was published on factory test data and on market and economic analysis of 5-kW residential power generators.
 - A report was published on an analysis of a 50-kW PEM system for commercial applications.

4. Natural gas engines.

- A report was published on reciprocating engines for stationary power generation.
- A workshop was held in San Diego in October 1999, and a final report was published.

5. The scoping study was completed and a report was published on the results.

Project Status: Commission participation in this target is ongoing.

TARGETS: 87.0 HYDROPOWER OPERATIONS, RELICENSING AND ENVIRONMENTAL ISSUES; 87.1/48 ENVIRONMENTAL ISSUES MANAGEMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; B.C. Hydro International Ltd.; HCI Publications; Iris Power Engineering Inc; Kearns & West Inc; EA Engineering; Science & Technology Inc; Lang, Railsback & Associates; Lockheed Martin Energy Research Corp

CEC Project Amount: 1999: \$ 71,400
2000: \$28,800
Total: \$100,200

Match Funding: 1999: \$826,738
2000: \$564,554
Total: \$1,391,292

Contractor Project Manager: Norris Hirota
(650) 855-2084

Commission Project Manager: Linda Spiegel
(916) 654-5061

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address the challenges facing the hydroelectric industry that come in the areas of Federal Energy Regulatory Commission (FERC) relicensing and environmental mitigation. Balancing the protection of fish and wildlife resources with multiple demands for water use can be optimized by utilizing credible scientific information, tools, and methods. The management of hydro project decommissioning, including impoundment sediment management (characterization, removal, and disposal), dam removal, and ecosystem restoration are complex technical issues for which little background science exists. This EPRI tiered target offers cost-effective solutions to address critical relicensing, environmental, and public issues related to the hydro industry, by utilizing the world-renowned expertise of EPRI scientists and engineers, forums for sharing information and capitalizing on the lessons learned by others, and leveraged development of solutions to common problems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability;
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment; and
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

Proposed Outcomes:

1. Provide information on relicensing best practices for the hydropower industry.
2. Provide information on worldwide technological developments relevant to the hydropower business.
3. Improve fish protection methods by providing scientific information, techniques, and guidance based on state-of-the-art and emerging methods for instream flow management.
4. Provide assessment methods for more accurately evaluating the effects of turbine entrainment and mortality on fish populations.
5. Provide information and tools for determining cost-effective upstream and downstream fish passage and protection needs for migratory and nonmigratory fish.
6. Provide information for water resources management to optimized power production while complying with environmental protection requirements.
7. Offer a cost-effective approach for site-specific environmental data gathering and ecosystem research needs while providing future communication links with the environmental management, regulatory, and research community.
8. Conduct a tailored Collaboration entitled "Sedimentation issues at hydroelectric facilities."

Actual Outcomes:

1. Best practices.
 - A Preferred Practices Guidebook was developed that outlines effective hydro relicensing practices.
 - The National Relicensing Group (NRG), sponsored by EPRI, developed a manual on best practices for hydropower relicensing entitled Hydro Relicensing Forum: Relicensing Strategies.
 - The NRG met three times in 2000 to discuss issues related to relicensing and to develop the best practices manual.
2. New information was provided in five reports for optimizing hydropower operations through rehabilitation,

upgrading, condition monitoring, and life extension of hydropower facilities.

3. Instream flow management.
 - EPRI's Individual-Based Instream Trout Model was developed and successfully tested.
 - A review and evaluation of state-of-the-art instream flow assessment methods was conducted, compiled in a draft report, peer-reviewed, and published in a final report.
4. Developed improved modeling approach for studying fish behavior and impacts of hydro systems on fish .
5. Fish passage and protection needs.
 - An evaluation was made of bar racks and louvers for preventing turbine entrainment and guiding fish to bypasses. Tests were conducted on lake sturgeon, shiners, walleye, smallmouth bass, and American eels, and results published in a report.
 - Two symposia were held and papers published on passage and protection of catadromous eels and green sturgeon.
6. New information was presented on the extent and severity of reservoir sedimentation problems in the United States and current practices to mitigate or prevent sediment-related problems, including a case study at a California hydroelectric project.
7. Support was provided for graduate research fellowships in Ecology and Hydrology.

Project Status: The Commission's participation in this target is ongoing.

TARGET 103/44 FISH PROTECTION ISSUES

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Alden Research Laboratory Inc; Applied Biomathematics Inc; Duke Energy Corporation; EA Engineering, Science & Technology; Langhei Ecology LLC; Lockheed Martin Energy Systems Inc; Tennessee Valley Authority; Tetra Tech Inc; Kenneth Rose

CEC Project Amount: 1999: \$262,700
2000: \$262,700
Total: \$525,400

Match Funding: 1999: \$2,838,013
2000: \$2,858,821
Total: \$ 5,696,834

Contractor Project Manager: Doug Dixon (804) 642-1025

Commission Project Manager: Linda Spiegel

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide methods for studying fish entrainment and impingement mortality and generate results for fish

population predictions that will be used to address biological community and biodiversity risks associated with power plant and industrial facilities operations. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This EPRI target supports cost-effective fish protection and facility operational decision-making.

This project supports the PIER Program objectives of:

- Improving the environment costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments; and
- Improving the public health costs/risks of California's electricity by protecting fish in cost effective ways to minimize environmental impacts on aquatic environments that impact humans.

Proposed Outcomes:

1. Provide California with effective "best technology available" (BTA) engineering methods for cooling system intakes.
2. Provide objective science and engineering to the California energy enterprise debate in water use impacts.
3. Develop accurate ecological risk assessment tools to assess the effects of power plant operation on individual fish and the risks to aquatic communities for cost-effective fish protection options.
4. Develop Aquatic Ecosystem Evaluation Methods, Ecological Risk Assessment Frameworks, Compensation Mechanisms in Fish Populations (CompMech), and Thermal Discharge Risk Analyses.

Actual Outcomes:

1. Intake fish protection system assessments.
 - A report was produced summarizing a review of fish protection technologies at cooling water intakes.
 - Research was conducted and a report produced on the effectiveness of bar racks and louvers for preventing passage of fish through turbines at hydroelectric projects.
 - Guidelines were published for selecting technologies appropriate for "best technology available" (BTA) analysis based on site-specific factors such as plant design, representative fish species present, and others. The guidelines will help California facilities determine their own best BTA options prior to construction.
2. Objective science and engineering on water use impacts.
 - Proceedings were published of a technical workshop on the Clean Water Act Section 316(b).

- A report was published on methods for evaluating nursery and spawning habits.
3. Ecological risk assessment methods.
 - New information was developed on ecological risk endpoints for abundant species. This project will provide a method for resource agencies to benchmark the risk of any impact on various species.
 - An ecological risk case study was conducted on Hudson River striped bass, applying the ecological risk endpoints method.
 - A report was published on performing a human health and ecological risk assessment using the RIVRISK software program.
 - A report was published on using water approach velocity as a screening tool.
 - A report was published on adapting risk analysis processes to 316(b) Tier 3 Assessments.
 - A database was compiled on entrainment survival for fish and other aquatic species.
 4. Aquatic ecosystem evaluation methods.
 - A catalog was published on assessment methods for evaluating the effects of power plant operations on aquatic communities.
 - A report was published on applying biocriteria as a concept, approach, and tool for assessing impacts of entrainment and impingement under 316(b).

Project Status: Commission participation in this target is ongoing.

ADVANCED FUEL CELLS (#165)

Contract #: 100-98-003 (#1)

Contractor and Major Subcontractors: Gas Technology Institute (GTI), Materials and Systems Research, Inc. (MSRI), Honeywell

Contract Amount: 1999: \$25,000 2000: \$43,000

Contractor Project Manager: Ron Edelstein
(847) 768-0898

Commission Project Manager: Mike Batham
(916) 654-4548

Project Description: The purpose of this project is to develop cost-effective, highly efficient fuel cell technology for distributed power generation from natural gas that has broad market implications for residential, commercial, industrial, and power generation customers. This project is designed to capitalize on the results of previous GRI research that identified innovative cell designs and materials to reduce the operating temperatures of solid oxide-fuel cells from 1000 degrees C to 700 degrees C. Those advances will enable large savings in the cost of the cells as well as the prospect of lower maintenance and longer life.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risk of California's electricity because fuel cells emit low levels of atmospheric emissions and reduce the level of noise pollution vis-a-vis large scale power plants; and
- Improving the energy cost and value of CA electricity by providing high, fuel-to-electricity conversion efficiency.

Proposed Outcomes:

1. Provide the design of a low-cost, high-efficiency advanced cell stack.
2. Provide fuel cell manufacturers with laboratory demonstrations of how to design and assemble solid oxide fuel cell stacks that operate below 700 degrees C with very high efficiencies and power densities.
3. By 2001, the project will result in fuel cell stacks that can be developed for under \$300 per kilowatt with electrical efficiencies greater than 50 percent.
4. By 2003, provide an evaluation of fuel processing options.

Actual Outcomes:

1. MSRI has successfully tested a 250W stack. A 100W stack was operated at 0.4 W/cm² for 500 hr with repeated thermal cycling and no voltage loss. The internally manifolded stack operated on hydrogen and natural gas. Scale-up from 2"x2" to 4"x4" stacks is complete. Key stack design and metallic interconnect patents have issued.

Project Status: The project is ongoing.

Energy-Related Environmental Research

GOLDEN EAGLES IN A PERILOUS LANDSCAPE: TRACKING THE EFFECTS OF MITIGATION FOR ENERGY BASED MORTALITY

Contract #: 500-97-036

Contractor and Major Subcontractors: University of California at Santa Cruz and H. Peters Consulting

Contract Amount: \$675,121

Contractor Project Manager: Grainger Hunt
(530) 336-7281

Commission Contract Manager: Dick Anderson
(916) 654-4166

Project Description: This purpose of this project is to assist in understanding the complex interactions of golden eagles with the electrical power producing Altamont Pass Wind Resource Area (WRA) structures. In the Altamont WRA, an estimated 40-60 golden eagles and several hundred red-tailed hawks are killed annually by collisions with wind turbines. Electrocutation is another source of golden eagle fatality, both within and outside the WRA. These fatalities are a concern for stakeholders and produce costly permitting delays.

This project supports the PIER Program objectives of:

- Improving the environmental costs/risk of California's electricity by providing critical information to help reduce golden eagle fatalities in the Altamont Pass WRA; and

- Improving the reliability/quality of California's electricity by providing information to overcome regulatory barriers to siting or replacing wind turbines.

Proposed Outcomes:

- Provide information focusing on whether the WRA-wide golden eagle population is stable, increasing in size or declining in size.
- Determine whether there is a correlation between golden eagle use of the WRA and ground squirrel concentrations.
- Determine whether ground squirrel concentrations are attracting golden eagles into risky situations.
- Document golden eagle use of the following areas:
 1. Where recent structural modifications have been made.
 2. Where wind turbines in high risk areas have been removed (determined by incidental carcass discoveries).
 3. Where there has been repowering of some areas with new, larger, more efficient wind turbines.
- Improve public perception of wind power because the net result of the industry's efforts to mitigate this issue can be directly measured.

Project Status: The final report draft is expected by June 2001, and the final report is anticipated in September.

GLOBAL CLIMATE CHANGE - CALIFORNIA IMPLICATIONS AND POTENTIAL COSTS

Contract Number: 500-97-043

Contractor and Major Subcontractors: Electric Power Research Institute (EPRI) and Charles Rivers Associates, Stratus Consulting, Exponent Health Group, and several professors from Yale, Stanford, U.C. Davis, MIT, University of Colorado, and Oregon State University.

Contract amount: \$2,159,800

Match funding: \$28,400,000

EPRI Project Manager: Richard Richels (650) 855-2602

Commission Contract Manager: Guido Franco (916) 654-3940

Project Description: The purpose of this project is to study the phenomenon of climate change, and from the understanding gained, provide the information necessary to evaluate the best options for addressing the impacts of climate change in the U.S. including a focus on California. This project will improve our understanding of the potential physical impacts of global climate change in California and the impacts of efforts to reduce greenhouse gas emissions on the State's economy, the State's energy system, and electricity production in particular.

PIER funding allows a more in-depth analysis in California than what would be gained by national studies alone. Specifically, this project will improve our understanding of the potential climatic changes in California, including the potential general impacts on ecosystems, agriculture, hydroelectric resources and water resources, as well as energy consumption and other areas affected by climate. This project will also identify potential adaptation measures to address the expected climate impacts. EPRI will estimate the direct economic impacts, including energy prices impacts that would be incurred in the next 30 years due to the implementation of national or international programs designed to reduce greenhouse gas emissions, such as the Kyoto Protocol.

This project supports the PIER program objective of:

- Reducing environmental and public health costs/risk of California's electricity by conducting research to support California energy policy initiatives and further research related to global climate change.

Proposed Outcomes:

- Assess the potential costs and implications to California of global climate change. The assessment will make extensive use of the existing framework and expertise developed by EPRI and its subcontractors for similar studies conducted at the national and international levels;

- Reduce the uncertainty in, and improve the performance of, general circulation and carbon cycle models used to predict climate change effects;
- Study the potential effects of climate change on human health, economic activities, and natural ecosystems;
- Evaluate regional impacts of possible climate changes, including potential effects in California on agriculture, forestry, and water resources. The project will also examine the economic implications of proposed climate change mitigation policies as they could affect California, such as increasing prices for electricity and fuels; and
- Enhance an integrated assessment framework and use it to examine alternative proposals for reducing greenhouse gases in terms of costs and benefits.

Project Status: The project is on schedule and within budget. Due to the large scope of this project, the Commission Contract Manager has created an external review team formed by representatives from different state agencies, such as the Department of Fish and Game, and the Department of Food and Agriculture. They are involved directly in the design of the different studies and will review the draft and final products. The aim of this effort is to make sure that the study results are directly applicable and relevant to agencies managing the state resources, including energy, that would be affected by global climate change.

The California specific products expected in the year 2000 include:

1. detailed climatic scenarios;
2. expected changes in vegetation patterns;
3. evaluation of health effects due to El Niño events;
4. preliminary economic evaluation of the potential impact of the Kyoto Protocol; and
5. preliminary evaluation of impacts on agriculture and water resources.

ELECTROTECHNOLOGY APPLICATIONS FOR POTABLE WATER PRODUCTION AND PROTECTION OF THE ENVIRONMENT

Contract #: 500-97-044

Contractor and Major Subcontractors: Southern California Edison (SCE) and Metropolitan Water District of Southern California; Orange County Water District; University of California, Riverside; Innovatech Corp.; Utility Technology Associates; Electric Power Research Institute (EPRI)

Contract Amount: \$2,889,678

Match Funding: \$13,936,267

Contractor Project Manager: Lory Larson (626) 815-0520

Commission Contract Manager: Wendell Bakken:
(916) 654-4042

Project Description: The purpose of this project is to develop electrotechnologies, which can produce new supplies of reliable and affordable drinking water, reduce electrical use to deliver and treat that water, and reduce the environmental problems created by current treatment and transport processes. Six innovative electrotechnology-based water treatment processes will be evaluated to: 1) investigate advanced oxidation processes, 2) evaluate biological denitrification, 3) study solids removal technologies, 4) assess salinity removal technologies, 5) investigate disinfection alternatives, 6) demonstrate solids processing techniques, 7) perform energy and process assessment for system optimization, and 8) investigate scale-up issues and provide technology transfer.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by avoiding electricity use and costs to transport water over long distances and by avoiding investments in long-distance water transfer projects.

Proposed Outcomes:

- Evaluate two advanced oxidation processes: pulsed UV/hydrogen peroxide and ozone/hydrogen peroxide, for their effectiveness in removing methyl tertiary butyl ether (MTBE), perchlorate, and other synthetic compounds from surface water and groundwater supplies.
- Demonstrate how biological denitrification helps reduce concentrations of nitrate in contaminated wells to acceptable limits so that these wells can be re-activated as drinking water sources.
- Evaluate the performance of solids removal technologies for surface water, municipal wastewater, and agricultural drainage water as a pretreatment for salinity removal processes.
- Evaluate the effectiveness of two, non-thermal desalination technologies for the demineralization of surface water, reclaimed water, and agricultural drainage water. The non-thermal desalination technologies to be evaluated are experimental membranes (reverse osmosis (RO) and nanofiltration (NF) membranes) and carbon aerogel capacitive deionization (CDI).
- Evaluate the effectiveness of pulsed-UV irradiation and ozone as physical, post-filtration disinfection processes for the inactivation of viruses, bacteria, and protozoa.
- Investigate the effectiveness of mechanical freeze-thaw conditioning to enhance the dewatering of waste-stream residuals (sludge) from both conventional and desalting water treatment processes.
- Conduct energy assessments of municipal water and wastewater unit processes to determine their energy use and water quality processing characteristics and to identify

areas for improvement through application of electrotechnologies.

- Evaluate preliminary scale-up issues for pulsed-UV irradiation, microfiltration for solids removal and desalting membranes. More specifically, a larger pulsed-UV treatment chamber, a demonstration MF system, and new, large diameter reverse osmosis membrane elements will be designed and tested for large-scale water and wastewater applications.
- Connect the results from the electrotechnology research conducted through this contract to the research and water utility industry which can apply the results to their own research and which can adopt the technologies into their water-utility operations.

Project Status: The project is on schedule and within budget.

CENTRAL VALLEY OZONE STUDY

Contract #: 700-98-027

Contractor: California Air Resources Board (CARB)

Contract Amount: 1999: \$3,000,000

Contractor Project Manager: Andrew Ranzieri
(916) 324-4069

CEC Project Manager: Guido Franco (916) 654-3940

Project Description: The purpose of this project is to participate, through an interagency agreement with the California Air Resources Board, in the Central California Ozone Study (CCOS) to gain a better understanding of the dynamics of the existing and expected ozone problem in Central California. Other participants in this study include several local air districts, the U.S. EPA, and private entities. The results of this study will shape the control strategies to be used in this region of California for at least the next decade. The area of study is much larger than that of earlier studies covering an area bounded by the Pacific Ocean to the west, the Sierra Nevada to the east, the end of the Sacramento Valley to the north, and the Mojave Desert to the south. The development of this information and modeling tools will also provide the opportunity to study new ways to use electricity to avoid or reduce air quality problems in this region.

This project supports the PIER program objective of:

- Improving the public health costs/risks of California's electricity by promoting a better understanding of the dynamics of the existing and expected ozone problem in Central California.

Project Status: Project is on schedule, on budget and is expected to achieve proposed outcomes.

TARGET 43 WATER QUALITY CRITERIA AND TOXICS IN AQUATIC ENVIRONMENTS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Great Lakes Environmental Center; University of Wisconsin; University of Trent; Tetra Tech; Fresh Water Institute; Water Environment Research Foundation; EA Engineering Science and Technology; United States Geological Survey; Allegheny Power; Frontier Geosciences; Battelle Northwest Laboratories; ICF Consultants

CEC Project Amount: 2000: \$120,000

Match Funding: 2000: \$1,541,861

Contractor Project Manager: John Goodrich-Mahoney (650) 855-5256

Commission Project Manager: Joe O'Hagan

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess the impacts of toxic chemicals in California's aquatic environments. Findings can be applied directly to meet specific technical challenges. They are also useful to the regulatory and scientific communities, helping to inform ongoing deliberations and to increase understanding of critical issues.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

Proposed Outcomes:

1. Upgrade the Dynamic Mercury Cycling Model, which models mercury deposition, transformation, and bioaccumulation in lakes.
2. Develop models for assessing metal toxicity on a site-specific basis.
3. Develop a guidance document for determining a site-specific criterion for selenium.
4. Evaluate and improve risk assessment methodologies for water quality criteria.
5. Provide information on the health risks of arsenic.
6. Improve the accuracy of criteria for contaminated sediments.
7. Assess the emerging field of biocriteria and its application to water bodies.

8. Explore the application of persistent bioaccumulative toxics (PBTs) to metals and inorganic metal compounds.

Actual Outcomes:

1. An upgraded version of the Dynamic Mercury Cycling Model was produced. The model will be helpful in assessing total maximum daily load of mercury in several large California lakes.
2. A biotic ligand model (BLM) for copper was developed. This model can be used to develop site-specific metal toxicity in California water bodies.
3. A technical workshop was held to develop a guidance document for determining a site-specific criterion for selenium.
4. Risk assessment methodologies.
 - A report was published evaluating of current Federal risk-assessment methodologies.
 - A user's guide to RIVRISK, Version 5.0, was published. This model can be used to assess human health and ecological risks associated with industrial and power plant chemical and thermal releases to rivers.
 - EPRI prepared technical comments on EPA's proposed rule on human health methodology.
5. A peer-reviewed white paper was published summarizing EPRI research conducted over several years on the health risks of arsenic. EPRI also prepared technical comments on the EPA proposed rule on arsenic.
6. Contaminated sediments.
 - A report was published providing a critical assessment and review of EPA activities and research on contaminated sediments.
 - Proceedings were published of an EPRI workshop on sediment guidance and regulation.
7. Proceedings were published of an EPRI-hosted national workshop on biocriteria.
8. A workshop was held to explore the state-of-the-science concerning application of PBTs to metals and inorganic metal compounds, principally mercury and lead.

Project Status: The Commission's participation in this target is ongoing.

TARGET 105/46 FACILITIES WATER MANAGEMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Di Filippo Michael; Lytle Mel C; Alabama Power Company; BetzDearborn, Inc.; Gannett Fleming, Inc.; Puckorius & Associates Inc; University of California, Berkeley; University of Iowa; University of Southern California; Water Systems Specialists Inc

CEC Project Amount: 1999: \$228,405
2000: \$55,200
Total: \$283,605

Match Funding: 1999: \$856,815
2000: \$990,880
Total: \$1,847,695

Contractor Project Manager: Kent Zammit
(650) 855-2097

Commission Project Manager: Joe O'Hagan
(916) 653-1651

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources.
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

Proposed Outcomes:

1. Provide biofouling control and plant performance strategies.
2. Provide cost-effective wastewater treatment strategies.
3. Provide cooling water treatment and reuse strategies.
4. Conduct a Tailored Collaboration entitled "Degraded Water Study," to assess the use of degraded water sources within California in lieu of potable sources for closed-loop cooling of new power generation projects.
5. Conduct a Tailored Collaboration entitled "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies" for evaluation of the opportunities to implement lower water use options for power plant cooling in California.

Actual Outcomes:

1. Biofouling control.
 - A preliminary report was published on evaluation of non-toxic biofouling technologies.
 - A report was published on follow-up bench-scale tests

and power plant slipstream evaluation of non-toxic biofouling technologies.

- The 10th International Zebra Mussel Conference was cosponsored by EPRI.
- Research was conducted on controlling the biofouling of heat exchangers and cooling systems using new chemical and nonchemical macrofouling control technologies—in preparation for publication in 2001 of the *Revised Guidelines for Macrofouling Control Technology*.

2. Wastewater treatment.

- A report was published on the successful use of genetically engineered plants with superior capabilities for the phytoremediation of heavy metals such as selenium, molybdenum, cadmium, and tungsten.
- The use of iron-coated sand was demonstrated for reducing solid waste volumes by orders of magnitude relative to iron co-precipitation, the current industry standard.
- An assessment report, field test report, and guidelines were published for treating water using plant impounds in which toxic substances precipitate in holding ponds.
- A report was published on research conducted at the Chevron constructed wetland treatment system on San Francisco Bay on the role of wetland plants in the volatilization of selenium and other toxic trace elements.
- Research was conducted on wastewater treatment for removal of nitrogen compounds—in preparation for publication in 2001 of the *Guidelines for Wastewater Treatment for Removal of Nitrogen Compounds*.

3. Cooling water treatment and reuse.

- Results were published on the first pilot study of alternative biocide compounds for control of microfouling and macrofouling in cooling towers.
- Case studies were conducted on the recycling and reuse of power plant water and wastewater to help reduce the cost and environmental consequences of water purchase, use, and discharge—in preparation of publication in 2001 of new guidelines.

4. A report on the use of degraded water for power plant cooling is under review.

5. A report evaluating the costs, design impacts, effects on generation capacity, and research and development needs for applying wet, dry, hybrid wet/dry, and alternative cooling systems for power plant cooling in California is under review.

Status: The Commission's participation in this target is ongoing.

Strategic Energy Research

ELECTRIC SYSTEM SEISMIC SAFETY AND RELIABILITY

Contract: 500-97-010

Contractor and Major Subcontractors: Pacific Gas and Electric Company and University of California, Berkeley Pacific Earthquake Engineering Research Center (PEER)

Contract Amount: \$1,000,000

Contractor Project Manager: Dr. William (Woody) Savage (415) 973-3116

Commission Contract Manager: Robert Anderson (916) 654-3836

Project Description: The purpose of this project is to support several major research projects in the field of electric system seismic safety and reliability. Projects ranged from the shake table testing of electric bushings and the collection of soil data at existing substations, to the development of a rapid response, strong ground shaking contour map program and related strong ground motion attenuation curves. Some of the early products have already been incorporated by a major California utility in their risk management practices. This contract was extended through January 31, 2000, due to the interruption of research report preparation by investigators assigned to assess damage in Turkey after the August 17, 1999, magnitude 7.4 Kocaeli earthquake.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing the vulnerability of the electric transmission and distribution system due to damage caused by a major earthquake, continuation of power in an area affected by an earthquake and/or by the rapid recovery of the electric service. This rapid recovery will allow for a shortened interruption to emergency services and businesses due to the loss of electric power.

Proposed Outcomes:

- Improvements to installed utility equipment will be identified and tested, and the potential for future disruptions due to earthquake-induced damage can be reduced.
- Develop improved assessments of shaking-caused permanent ground deformation hazards in formats that the utility can directly use for evaluating electric system vulnerabilities.
- Examine the process of fire initiation during power restoration following earthquakes to evaluate various means to reduce the risk of starting fires.

- Develop the capability to analyze data from distant seismographic instruments to accurately predict the pattern and severity of strong earthquake shaking anywhere in the state.

Project status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

DEVELOPMENT OF A REAL-TIME MONITORING DYNAMIC RATING SYSTEM FOR OVERHEAD LINES

Contract #: 500-98-034

Contractor: Engineering Data Management, Inc. (EDM)

Contract Amount: \$499,402

Match Funding: \$510,019

EDM: \$230,019

EPRI: \$280,000

Contractor Project Manager: Andrew H. Stewart (970) 204-4001

Commission Contract Manager: Linda Davis (916) 654-3848

Project Description: This project develops a monitoring system which provides instantaneous information to electric grid operators about monitored transmission lines' power-carrying capacity and safety code compliance. The system provides real time monitoring to ensure power line ground clearance requirements are met and calculates the maximum power transfer capability of monitored lines based on actual position of the conductor. Assuring maximum power transfer capability over existing lines increases the efficient use of overhead transmission lines and reduces the need for new power lines.

This project improves the safety and the reliability of California's electricity by providing a system to monitor transmission line-to-ground clearance thereby avoiding fires and electrical shock hazard and reducing power outages caused by sagging lines.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing a system to reduce power outages caused by sagging lines;
- Improving the energy cost/value of California's electricity by improving the efficiency and power carrying capability of monitored lines and reducing costs of power delivery;
- Improving the environmental and public health costs/risks of California's electricity by reducing losses and avoiding fires; and

- Improving the safety of California's electricity by monitoring transmission line-to-ground clearance thereby avoiding electrical shock hazard.

Proposed Outcomes:

- Improving the ability to monitor the line to ground clearance of transmission lines should help avoid fires and electrical shock hazard and reduce power outages caused by sagging lines.
- Reduce energy cost by improving the efficiency and power carrying capability of monitored lines, thereby improving line utilization and reducing costs of power delivery as well as reducing losses.
- Able to measure clearances and sags with an accuracy of better than ± 2 inches.
- Capable of threefold use:
- Real-time monitoring/dynamic rating;
- Evaluating the performance of existing lines to re-rate their capability; and
- Monitoring the status of clearances/sags in "safety critical" areas.
- Installation time for sensor system field hardware of less than six hours.
- Capable of operation in remote sites through use of solar power supply plus capability for simple reconfiguration to AC power.
- Capable of reliable operation during daylight and at night.
- Capable of reliable operation in temperatures ranging from -10 degrees F to $+120$ degrees F.
- Capable of ready integration of additional devices for making ancillary measurements such as wind speed and ambient temperature.
- Capable of remote sensor system operation through cellular, radio, or satellite communication.
- Capable of autonomous remote reboot of hardware in case of an operational or environmental anomaly that causes proper operation to cease.
- The target maximum cost for a complete system is \$45,000, with additional sensor packages available for utilization with the system at a cost of \$15,000 each. These costs do not include installation labor and expenses, nor the costs for the computer, telephone line, and networking that will be required to support effective use of the system.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

2 KWH FLYWHEEL ENERGY STORAGE SYSTEM

Contract #: 500-98-036

Contractor: Trinity Flywheel Power

Contract Amount: \$1,057,406

Match Funding: \$1,062,494

Contractor Project Manager: John Eastwood
(415) 362-0634

Commission Contract Manager: Jamie Patterson
(916) 654-4819

Project Description: The purpose of this project is to demonstrate a two-kWh flywheel energy storage system for distributed generation and load shifting that will be directly scaleable to ten kWh. The technical objective of this project is the design, fabrication, and operation of a cost-effective composite flywheel having emphasis upon both high specific energy and low idling losses.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by providing a load shifting technology that can be used during peak load periods.

Proposed Outcomes:

- One operating two-kWh flywheel energy storage system for distributed generation and load shifting that will be directly scaleable to ten kWh.
- Complete the transition from further development of the technology to volume manufacturing.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

LIGHT ACTIVATED SURGE PROTECTION THYRISTOR (LASPT) FOR DISTRIBUTION SYSTEM RELIABILITY

Contract #: 500-98-038

Contractor and Major Subcontractors: Energy Compression Research Corporation (ECRC) was the contractor. On October 6, 1999, the contract was novated from ECRC to OptiSwitch Technology, Inc. (OTC). Subcontractors include Silicon Power Corporation; SRI International; and Telecom Data.

Contract Amount: \$494,239

Match Funding: \$93,292 (ECRC)

Contractor Project Manager: Dr. David Giorgi
(858) 452-8787, ext. 125

Commission Contract Manager: Jon D. Edwards
(916) 654-4851

Project Description: The purpose of this project is to determine whether it is technically and economically feasible to replace electronically activated surge protection thyristors currently installed on high-power transmission and distribution systems with the improved custom light activated surge protection thyristors. Specifically, this Contractor will design, fabricate, and laboratory test the

LASPT to determine if it has superior technical performance characteristics to that of a conventional thyristor.

This project contributes to the PIER program objective of:

- Improving reliability of California's electricity system by lowering the state's vulnerability to catastrophic outages by preventing cascading power failures due to rapid surges. This project also contributes to the PIER Program's strategic energy research objective under the revolutionary science attribute of designing and manufacturing a unique optical coupling to complete the development of the custom LASPT.

Proposed Outcomes:

- Design, fabrication, and laboratory testing of a light activated surge protection thyristor.
- Exhibit a surge response rate of 10 k (kilo) amps per microsecond (10 kA/μs);
- Exhibit a peak current rate of 15 k (kilo) amps (15kA); and
- Exhibit minimum blocking voltage capability of 2700 volts (V).

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

INTELLIGENT SOFTWARE AGENTS FOR CONTROL & SCHEDULING OF DISTRIBUTED GENERATION

Contract #: 500-98-040

Contractor and Major Subcontractors: Alternative Energy Systems Consulting, Inc., and Reticular Systems Inc.

Contract Amount: \$554,010

Match Funding: \$34,347

Contractor Project Manager: Gerald L. Gibson (619) 560-7182

Commission Contract Manager: Jamie Patterson (916) 654-4819

Project Description: The purpose of this project is to demonstrate the use of intelligent software agents for control and scheduling of distributed generation. The California Alliance for Distributed Energy Resources (CADER) projects that distributed generation could supply 20 – 40 percent of the estimated capacity that will be needed in California to both replace retired generating plants and to meet increased loads.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by enabling a greater participation by owners of distributed energy resources through the use of intelligent software agents for control and scheduling of distributed

generation. This will reduce distribution system congestion and avoid distribution line losses.

Proposed Outcomes: A demonstration of intelligent software agents successfully controlling and scheduling distributed energy generation resources.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

SAGGING LINE MITIGATOR (SLIM)

Contract #: 500-98-042

Contractor and Major Subcontractors: Material Integrity Solutions, Inc. (MIS) and Dr. Duch Hai Nguyen of Hydro Quebec (IREQ); Dariush Shirmohammadi, Ph.D.; Expert Power Engineering Consultant.

Contract Amount: \$900,000

Match Funding: \$78,920

Contractor Project Manager: Dr. Manuchehr Shirmohammadi (510) 594-0300 x202

Commission Contract Manager: Jon D. Edwards (916) 654-4851

Project Description: The purpose of the SLIM project will develop and test a sagging line mitigator to automatically counteract the sagging of high voltage transmission lines due to high ambient temperature and current flows. The product to be developed has the potential to revolutionize treatment of overhead transmission lines for both retrofitting of existing lines and construction of new lines. It will significantly reduce the risk of forest fires and brownouts caused by sagging lines, increase the efficiency of energy transfer, delays the need for additional line capacity and delay the construction of new lines. Used on new lines, this product will allow reduced tower height and/or increased distance between towers.

This project supports the PIER Program objectives of:

- Improving reliability and quality of California's electricity system by reducing the risk of brownouts (the curtailment of electric deliveries due to line capacity constraints) and power supply interruptions;
- Improving the safety of California's electricity by significantly reducing the risk of electrocution and fires caused by sagging transmission and distributions lines; and
- Reducing the environmental and public health risks/costs of California's electricity system by avoiding the need to build additional transmission towers.

Proposed Outcomes:

- Complete design and analysis work for the proposed SLIM device;

- Conduct rigorous prototype testing for applicability; proof of concept and design refinements;
- Develop manufacturing plans for the SLIM device.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

ELECTRIC SYSTEM SEISMIC SAFETY AND RELIABILITY

Sole-Source Agreement #: 700-99-002

Contractors: Pacific Gas & Electric (PG&E) and the Pacific Earthquake Engineering Research Center (PEER)

Contract Amount: \$3,000,000 (1999/00)
\$1,500,000 (2000/01)

Match Funding: \$1,000,000 (PG&E)
\$4,500,000 (CalTrans)

Total Contract: \$4,500,000

Total Match Funding: Up to \$5,500,000 (CalTrans up to \$4.5 million for 3 years)

PG&E/PEER Project Manager: Dr. William (Woody) Savage (415) 973-3116

Commission Project Manager: Bob Anderson (916) 654-3836

Project Description: The purpose of this project is to develop technologies and protocols to mitigate the vulnerability of electric systems to damage caused by earthquakes. Additionally, PG&E-PEER will develop assessment techniques to evaluate damage to electric systems caused by earthquakes and to assess fiscal impacts due to the loss of electric service to the community.

PEER is a consortium of 18 research universities located in California and other western states that has received National Science Foundation support for research in earthquake engineering and related fields. The PG&E-PEER Business and Industry Partnership was formed in 1996 to address, in a user-driven manner, important earthquake issues encountered by electric utilities operating in earthquake-prone regions.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by reducing the vulnerability of the electric transmission and distribution system due to damage caused by a major earthquake, continuation of power in an area affected by an earthquake and/or by the rapid recovery of the electric service. This rapid recovery will allow for a shortened interruption to emergency services and businesses due to the loss of electric power.

Project Status: The Commission approved the contract on

the November 3, 1999. The contract was initiated in March 2000 and runs through December 31, 2002. The contract has three phases. The work performed under the contract is completing the first phase and has started the second phase.

ELECTRIC SYSTEM RELIABILITY ENHANCEMENTS

Agreement #: 150-99-003

Agency Partners: Lawrence Berkeley National Laboratory (LBNL); and the Consortium for Electric Reliability Technology (CERTS); Oak Ridge National Laboratory (ORNL); Edison International; Power Systems Engineering Research Consortium (PSERC); Sandia National Laboratory (SNL); Electric Power Research Institute (EPRI); California Independent System Operator (CAISO).

Commission Funding: \$7,200,000
\$4,800,000 (1999/00)
\$2,400,000 (2000/01)

DOE Match Funding: \$12,900,000
\$2,500,000 (1999)
\$2,400,000 (2000)
\$8,000,000 (2001)

LBNL Project Manager: Joe Eto (510) 486-7284

LBNL Project Contact: Rich Wilson (510) 486-7391

Commission Contract Manager: Don Kondoleon (916) 654-3918

Project Description: The purpose of this project is to address the transition of California's electricity supply and delivery infrastructures from vertically integrated, regulated and government-controlled organizations to desegregated, competitive market-driven institutions. Power supply, network management and control systems are being driven to find new solutions to the traditional methods used to ensure stable power flows, frequency and voltage control. This intergovernmental agreement will provide integrated research and technology development that will help produce quicker and more flexible options for meeting the reliability, stability and ancillary service needs of California's electricity consumers

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity infrastructure by finding new solutions for a continued stable power supply for a deregulated electricity market; and
- Improving the energy cost/value of California's electricity by increasing the efficiency of California's competitive electricity market.

Project Status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

TARGET 57/30 GRID PLANNING & DEVELOPMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; California Institute Of Technology; Canadian Electricity Association; Carnegie Mellon University; Cornell University; ESEERCO; Harvard University; Honeywell Inc; Howard University; Iowa State University; Michigan Technological University; Mississippi State University; New Mexico State University; P Plus Corporation; Power Technologies Inc; PSERC; Purdue Research Foundation; Southern Company Services Inc; Texas Engineering Experiment Station; University of Washington

CEC Project Amount: 1999: \$180,000
2000: \$180,000
Total: \$360,000

Match Funding: 1998: \$4,838,558
1999: \$2,206,917
2000: \$2,282,943
Total: \$9,328,418

Contractor Project Manager: Dan Sobajic (650) 855-8537

Commission Project Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to help grid planners have ample lead-time to prepare for the occasional bulk power transfer. Presently, they are responsible for facilitating hundreds of electricity sales and purchases each day. Bids must be processed in near real time and congestion issues must be resolved on the fly. Grid planning is becoming increasingly complex and labor intensive. This situation is directly at odds with dwindling work forces and loss of experienced personnel and the public demand for lower cost energy. To address this situation, EPRI is providing advanced analysis tools and enhanced communication systems. EPRI's Grid Planning and Development program provides a comprehensive portfolio of technology solutions for coping with the short-, mid-, and long-term planning and design demands of a changing industry. While the industry continues to change, the need to deliver reliable economical power will not. This target delivers planning aids and operator-training tools that improve grid utilization, reduce operating costs, and ensure system security.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing advanced analysis tools and enhanced communication systems which will enhance grid planning

in today's high transaction environment while maintaining system security; and

- Improving the energy cost/value of California's electricity by improving grid utilization and reducing operating costs through the development and application of advanced tools and communications systems.

Proposed Outcomes:

1. Provide software, methods, and information to increase the reliability of the California transmission grid.

Actual Outcomes:

1. Software, methods, and information to increase grid reliability.
 - Information was provided that will assist the CA-ISO and California energy companies in designing rates and measuring ancillary services. Detailed information was provided on measuring three ancillary services—regulation, load following, and black start—and on certification testing for black start.
 - Versions 5.0 and 5.1 were released of EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS) Program, which allows grid planners to simulate outages and study their effect on system reliability after taking suitable corrective action.
 - Version 1.2 was released of Composite Reliability Assessment by Monte Carlo (CREAM), which simulates the composite effects of generation and transmission outages.
 - Two software programs were released, and two reports were published on, simulation of complex systems, including a report on prototype intelligent software agents for trading electricity.
 - A methodology was produced for evaluating short-term risk in power system planning in the presence of load forecast and fuel price uncertainty.
 - Tools were developed to evaluate the annual production cost of electricity as a function of uncertainty in generator availability.
 - Version 5.2 was released of EPRI's Small Signal Stability Program (SSSP), which identifies the causes of power system instability and pinpoints the location of technologies to mitigate the problems.
 - Version 5.2 was released of EPRI's Voltage Stability Program (VSTAB), which determines areas that are prone to voltage instability.
 - Version 5.2 was released of EPRI's Dynamic Reduction Program (DYNRED), which reduces large power system models to lower-order models that retain the characteristics of the original models while significantly reducing the computer time required to perform studies.
 - The Common Information Model (CIM) was extended to planning applications, enabling planners to base

their studies on operating data and to more closely cooperate with CA-ISO operators.

- Version 5.2 was released of EPRI's Extended Transient Mid-term Stability Program (ETMSP), which allows CA-ISO to conduct mid-term simulations for nonlinear stability analysis of the power system.
- The Off-Line Transfer Capability Evaluation (TRACE) software program was released, and a training workshop was held. This program will allow CA-ISO to increase transmission service revenues by accurately determining the maximum available transfer capability.
- A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
- A workshop was held for regional transmission organizations (RTOs) and independent system operators (ISOs), and proceedings of the workshop were published.

Project Status: The Commission's participation in this target is ongoing.

TARGETS: 64/24 DISTRIBUTED RESOURCES (DR) INFORMATION AND TOOLS FOR BUSINESS STRATEGY DEVELOPMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Christensen & Associates, Inc.; Daniel Mann Johnson Mendenhall; Edison Technology Solutions; Electrical Distribution Design Inc; Energy Signature Associates, Inc.; Erin Engineering and Research, Inc.; Hagler Bailly Consulting, Inc.; Materials and Systems Research, Inc.; National Rural Electric Cooperative Association; NEOS Corporation; Ontario Power Technologies; Proton Energy Systems, Inc.; Raytheon Engineers & Constructors, Inc; Resource Dynamics Corporation; Utility Consulting International.

Contract Amount: 1999: \$315,750
2000: \$280,500
Total: \$596,250

Match Funding: 1999: \$2,989,356
2000: \$4,075,981
Total: \$7,065,337

Contractor Project Manager: Dan Rastler (650) 855-2521

Commission Project Manager: Jairam Gopal
(916) 654-4880

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide the Commission with information and tools to enable California ratepayers and energy providers realize the full potential of DR-based business strategies. EPRI

involvement in DR research provides the unique access and intelligence necessary to identify new markets niches, improve the use of generation and T&D assets, and evaluate DR-based solutions for commercial and industrial ratepayers and business opportunities for energy providers. The target focuses on creating integrated, dependable, packaged solutions and providing information to better understand the DR market, both locally and globally. This EPRI target provides information to support the planning and deployment of DR projects, understand the impacts of DR on utility distribution systems, and evaluate the integration, management, and control of DR technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options for energy companies to utilize to provide unique solutions for their customers to address peaking power issues, to enhance their system reliability (system voltage control) and to assure power quality;
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed generating technologies and strategies that potentially, provide lower delivered electricity cost than central station power; and
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell and other environmentally preferred DR technologies that can be utilized throughout the State replacing traditional central station power.

Proposed Outcomes:

1. Provide strategic information on the DR business environment, trends, technologies, customers, and markets to enable the application of DR technologies in California.
2. Provide detailed information to assist distribution planners in integrating DR in utility systems.
3. Provide detailed information that allows for the analysis of DR application for energy service risk management.
4. Conduct a Tailored collaboration entitled "Microturbine Testing and Performance Evaluation" to validate the performance, reliability, operability, and maintainability of emerging microturbine technologies.

Actual Outcomes:

1. Strategic information on the DR business environment, trends, technologies, customers, and markets.
 - A regional market analysis was published, providing quantitative information on the potential size, market drivers, and opportunities for DR business cases.
 - An analysis was conducted, and findings published, of the strategic value of distributed power to distribution systems.

- The EPRI DR Technology Assessment Guide (DR-TAG) was published, providing a one-stop source for information on DR technologies, markets, and distribution planning. An on-line version of the tool is in development.
 - A new report was published on the environmental performance, regulation, and permitting requirements for DR.
 - A report was published on straw man object models for DR in Utility Communications Architecture (UCA).
 - A report was published on the use of DR in the emerging e-commerce environment.
 - A report was updated, a presentation package prepared, and a training workshop offered on the strategic role of DR in capacity planning.
 - Educational materials were produced to assist the CEC in educating entities in California about the technologies, issues, benefits, and risks of DR.
 - A training workshop was offered on Evaluating District Energy/CHP Projects.
 - A quarterly newsletter was published with latest breaking information on DR technologies and market developments.
 - EPRI hosted annual national DR Conferences to bring together investor-owned utilities, rural cooperatives, and municipal utilities.
 - EPRI hosted the DR Technology Business Venture Forum to bring together leading DR technology companies, electric utilities, and investors to exchange information related to business and investment opportunities.
2. Information to assist distribution planners in integrating DR in utility systems.
 - A report was published on distribution system behavior on urban and rural feeders.
 - A report was published on analytical models for assessing the design implications of distributed generation and storage.
 - A report was published on current interconnection practice and a unified approach.
 - A white paper was published on results of the IEEE interconnection standard working group.
 - A tech brief was published on interconnection and system impacts.
 - A DR Electrical Database and DR Engineering Guide were published.
 3. Information to allow analysis of DR application for energy service risk management.
 - A report was published on the role of DR in business strategies for risk management.
 - A report was published entitled Scenarios of Distributed Resources as Disruptive Technologies.
 4. More than 30 microturbines were tested, and findings were summarized in a final report.

Project Status: The Commission's participation in this target is ongoing.

DISTRIBUTED GENERATION (#733)

Contract #: 100-98-003 (#2)

Contractor and Major Subcontractors: Gas Technology Institute (GTI), KN Services, Onsite Sycom, AEC

Contract Amount: 1999: \$12,500
2000: \$28,500

Contractor Project Manager: Ron Edelstein
(847) 768-0898

Commission Project Manager: Scott Tomashefsky
(916) 654-4896

Project Description: The purpose of this project is to identify the application characteristics and technical requirements for the strategic utilization of gas-fired distributed generation beyond the electric distribution substation. The tasks undertaken in this program include 1) preparing an economic assessment of the market potential for installing distributed generation units, 2) developing modeling tools to identify options available to customers, and 3) developing integrated interconnection systems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by utilizing natural gas-fired distributed generation technologies; and
- Improving the public health costs/risks of California's electricity by advancing the use of low-emission natural gas.

Proposed Outcomes: During 2000, the following tasks will be completed:

1. Provide benefits, impacts, and issues information from four field test applications;
2. Provide two advanced controls and communications systems for distributed generation; and
3. Provide reports on infrastructure and interconnection system requirements, as well as communication protocol needs.

Actual Outcomes:

1. Provide benefits, impacts, and issues information from four field test applications:
 - Beta version of D-Gen Pro (Version 3) made available for user testing.
2. Provide two advanced controls and communications systems for distributed generation:
 - Installed a 1.2 MW gas turbine genset with novel communication/control equipment has been installed at Texas Tech.

- A retrofit of the existing reciprocating engine facility at Lovelace Medical Center, a 235-bed, full service hospital, located in Albuquerque, New Mexico was recently completed. A new communication/control system was installed to enable the hospital to benefit from instantaneous interruptible electric power rates.

3. Provide reports on infrastructure and interconnection system requirements and communications protocol needs:

Project Status: The project is still on budget, but some deliverables have been delayed until 2001.

PROJECTS FUNDED THROUGH THE ENERGY INNOVATIONS SMALL GRANT PROGRAMS – IN-PROGRESS

SOLICITATION 99-01 AWARDS**Proposals Received: 89****Passed Screening: 41****SDSU Program Administrator:****Commission Program Manager:****Approved: August 11, 1999****Grants Approved: 13 (\$973,851)****Grants Funded: 13 (\$973,851)****Hal Clark (619) 594-1158****Philip Misemer (916) 654-4552****ELECTROSYNTHESIS OF DEVICE QUALITY
SEMICONDUCTOR FILMS****EISG Grant Number:** 99-01**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Shalini Menezes (805) 492-9814**Organization:** InterPhases Research**Grant Amount:** \$75,000**Grant Term:** 18 Months

Project Description: The purpose of this project is to research the feasibility of an innovative electrochemical process that could be used in fabricating high quality thin films for copper indium diselenide photovoltaic (PV) modules. The process is designed to be simpler and more cost effective than current thin-film PV processes and is capable of being scaled up to large-area modules for manufacturing purposes.

Proposed Outcomes:

- Methodology for synthesizing consistent high quality copper selenide (CuSe) films using a new electrodeposition process.
- Precise control of film growth by regulating cycles using a specially designed diffusion layer deposition apparatus.

Anticipated Benefits:

- Reduce the cost of manufacturing large-area copper indium diselenide (CIS) PV modules.
- Eliminate expensive vacuum processing and vapor deposition procedure.
- Thin-film PV technologies, such as copper indium diselenide, are projected to reduce PV manufacturing costs by 75 percent.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 60% complete overall
- Design and testing of deposition apparatus 90% complete.
- Investigation of reaction mechanism and process parameters 80% complete.

- EMLE approach development for CUSE film 60% complete.
- Characterization of electrosynthesized films 0% complete.

VENTILATION MEASUREMENT AND CONTROL**EISG Grant Number:** 99-02**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Clifford Federspiel (510) 526-7484**Organization:** Federspiel Controls**Grant Amount:** \$74,970**Grant Term:** 15 Months

Project Description: The purpose of this project is to research the feasibility of producing a prototype, air flow measurement device for ventilation systems that is energy efficient, accurate, cost effective and maintenance free. This technology will be used to measure and control outdoor intake airflow rates, exhaust airflow rates and the airflow rates supplied to occupied spaces in buildings.

Proposed Outcomes:

- Prototype air flow device capable of measuring actual air flow within +/- 10 percent over the full range of operating conditions.
- Control logic and methodology for fan pressure resetting and demand-controlled ventilation.

Anticipated Benefits:

- Design that is less prone to fouling, is sensitive to variations in airflow velocity distribution within the duct and requires less maintenance.
- Reduce the cost to manufacture and install using low cost components and eliminate the need for a separate duct section dedicated to airflow measurement.
- Potential to reduce energy consumption in California by .055 quads (1 quad = 2.93×10^{12} kWh), of which .035 quads is related to reduced electrical consumption equivalent to \$326 million per year.

Project Status as of 11/15/00.

- Applicant was granted a 3-month, no cost extension
- Within budget
- 65% complete overall

- The correlation function that allows the air-flow measurement device to measure flow rate in both directions has been completed
- Sensitivity analysis has been completed and confirms that flow measurement accuracy of the device should exceed the accuracy of conventional pitot tubes
- Test stand fabrication has been completed
- Prototype construction complete
- Test accuracy 40% complete

CONTROL OF ON-OFF EQUIPMENT IN BUILDINGS

EISG Grant Number: 99-03

PIER Area: Building End-Use Efficiency

Principal Investigator: David Auslander (510) 642-4930

Organization: UC Berkeley

Grant Amount: \$75,000

Grant Term: 16 Months

Project Description: The purpose of this project is to research the feasibility of using new control strategy for the operation of On-Off HVAC systems and subsystems within commercial buildings. The control logic would be designed to minimize start-stop cycling frequency while ensuring that the variation in the process remains within acceptable limits.

Proposed Outcomes:

- Computer simulation that establishes the energy efficiency, temperature variation and maintenance impact of the proposed control strategy that incorporates state transition logic of multi-stage HVAC equipment and capacity control logic.
- Performance comparison of the new control logic with existing level-crossing logic.

Anticipated Benefits:

- Increase the operating efficiency and reduce maintenance costs of HVAC and refrigeration systems through improved control logic that reduces the cycling frequency.
- Potential to reduce energy consumption in California by .15 quads (1 quad = 2.93×10^{12} kWh), of which .084 quads would be related to reduced electrical consumption equivalent to \$1.97 billion per year.

Project Status as of 11/15/00:

- On Schedule
- Within budget
- 90% complete overall.
- The development of capacity control logic is complete.
- Development of state charts for operation of a multi-stage heating and cooling system is 100% complete.
- Computer simulation software is approximately 60% complete.

PROCESS FOR CONVERTING SEWAGE SLUDGE AND MUNICIPAL SOLID WASTES TO CLEAN FUELS

EISG Grant Number: 99-04

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Radon Tolman (505) 982-9912

Organization: Environmental Energy Systems Inc.

Grant Amount: \$75,000

Grant Term: 7 Months

Project Description: The purpose of this project is to research the feasibility of producing hydrogen and other clean fuels from wet biomass, sewage sludge and municipal solid wastes. The system would use the output of an aerobic (oxygen present) digester in combination with an innovative heat recovery steam generator that uses a water gasification process which is capable of accepting solutions of minerals and metals in slurries and emulsions without corrosion and deposition on heat transfer surfaces.

Proposed Outcomes:

- Quantify and analyze the liquids, gases and solid residues produced from a bench-scale prototype using the output of an aerobic digester as the feedstock.
- Quantify the fuel values and requirements for additional cleaning / treatment of the resulting fuels for use in gas turbines for electric generation.
- Assess the mass and energy balance, system optimization and economic feasibility.

Anticipated Benefits:

- Achieve 40 percent thermal efficiency in processing wet biomass sludge into electric power.
- Reduce quantity of secondary waste requiring landfill disposal. A typical sewage treatment plant- such as the plant in Encina, California- produces 90-100 metric tons per day of secondary waste and pays \$24 per wet ton for landfill disposal.
- Reduce need for landfill leachate collection and treatment and landfill gas recovery.

Project Status as of 11/15/00:

- 100% Complete
- Completed on schedule
- Completed within budget
- All tasks in Statement of Work were completed.
- Primary project objectives were successfully achieved.
 - Gasification process was successful in converting 98% of the carbon in wet biomass to gases of which approximately 40% were in the form of fuel gases that could be used for power generation.
 - Based on the gases produced a computer model projected a thermal efficiency of an integrated

combined cycle system to be approximately 60% which would be commercially competitive with power generated from conventional gas turbines.

- Draft final report has been submitted. The contractor has reviewed the report and submitted recommendations

NEW GENERATION THERMOELECTRIC MATERIALS FOR POWER GENERATION AND REFRIGERATION

EISG Grant Number: 99-05

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Angelica Stacy (510) 642-3450

Organization: UC Berkeley

Grant Amount: \$74,994

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of fabricating a thermoelectric material into a layer of microscopic unidirectional wires that are oriented perpendicular to the first layer which, in theory, should improve the conversion efficiency of generating electricity directly from heat. Thermoelectric power generators are produced by joining two thermoelectric materials with opposite charge carriers and applying heat to one side.

The thermoelectric fabrication be accomplished through the precise, electrodeposition of Cobalt Antimonide (CoSb_3) into a porous template. The objective is to produce a higher-efficiency thermoelectric material that can be used in power generation and refrigeration.

Proposed Outcomes:

- Optimized methodology for electrodeposition of CoSb_3 in a porous alumina template.
- Assessment of the thermoelectric properties of a fabricated array of CoSb_3 nanowires using electrodeposition.

Anticipated Benefits:

- Improve the efficiency of thermoelectric materials above the current state of the art by 10 percent.
- Advantages of thermoelectric power generation include: no emissions, no moving parts, quiet operation and can operate from waste heat.

Project Status as of 11/15/00.

- Running slightly behind schedule and will be asking for a no cost extension of term if unable to make up the slip in the schedule.
- Within budget
- 60% complete overall.

- Synthesized ionic liquids and determined that they are not the best solvent for this system
- Platinum electrodes prepared
- Electrodeposition experiments at constant current and constant voltage 100% complete
- Characterized products using X-ray diffraction, scanning electron microscopy, energy dispersive X-ray spectroscopy
- Above tasks completed for Bismuth telluride (Bi_2Te_3)
- Above tasks have begun using Cobalt triantimonide (CoSb_3)
- Method has been developed for the characterization of both the films and the nanowire arrays
- Characterization has been performed on test samples

RENEWABLE HYDROGEN FUEL PRODUCTION BY MICROALGAL PHOTOSYNTHESIS

EISG Grant Number: 99-06

PIER Area: Renewable Energy Technologies

Principal Investigator: Anastasios Melis (510) 642-8166

Organization: UC Berkeley

Grant Amount: \$75,000

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of increasing hydrogen production from the photosynthesis of algae. Three promising methodologies will be investigated: the effect of shifting the chemical equilibrium of the reaction, modifications to the growth media and the effect of diurnal cycles.

Proposed Outcomes:

- Optimized methodology for producing hydrogen from algae and sunlight.
- Solution for stopping photosynthetic oxygen production during the hydrogen production phase, which is important, since the presence of oxygen prevents the formation of enzymes needed for the production of hydrogen.

Anticipated Benefits:

- Increase hydrogen production efficiency from the current 10 percent to 20 percent of the theoretical maximum.
- Establish of a commercially sustainable H_2 production methodology utilizing green algae and sunlight.

Project Status as of 11/15/00.

- On schedule
- Within budget
- 75% complete overall.
- Improve the H_2 production by shifting forward the equilibrium of the reversible hydrogenase catalyzed reaction 100% complete

- Design and test cell growth media that accentuate the metabolism of H₂ production 70% complete
- Testing the effect of cycling stage on H₂ production process 30% complete
- Identify the rate-limiting step in the H₂ production process currently in progress

ROOFING TILE FOR NATURAL COOLING

EISG Grant Number: 99-07

PIER Area: Building End-Use Efficiency

Principal Investigator: Tom Dinwoodie
(510) 540-0550 x227

Organization: PowerLight Corporation

Grant Amount: \$74,885

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of an innovative residential roofing tile that will significantly reduce roof deck temperatures through passive convection and reflective means. Computer modeling and simulations will be performed and roof tile prototypes will be fabricated and tested.

Proposed Outcomes:

- Optimized roof tile design that possesses the desired conduction, radiation and convection heat transfer properties.
- Prototype roof tile capable of maintaining roof deck temperature at or below ambient temperature.

Anticipated Benefits:

- Projected annual energy savings of \$24-\$490 for a 2,000 sq-ft home ,depending on home construction and location.
- May permit the sealing of attic spaces in locations with high humidity for better moisture control.
- Tile design may be integrated with PV for added energy savings.

Project Status as of 11/15/00.

- On schedule after being granted a 3-month term extension.
- Within budget
- 90% complete overall
- Computer modeling 100% complete
- Laboratory testing has been completed
- Field testing at an independent laboratory is 100% complete
- Design optimization is 95% complete

MODELING GREENHOUSE TEMPERATURE FOR ENERGY EFFICIENT PRODUCTION

EISG Grant Number: 99-08

PIER Area: Industrial/Agriculture /Water End-Use Efficiency

Principal Investigator: J. Heinrich Lieth (530) 752-7189

Organization: UC Davis

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of creating models that accurately predict the effect of varying energy-related climate conditions on the growth of different hothouse plants. The models could then be used in computerized controls that allow HVAC systems to operate only when required to optimize plant growth or prevent plant damage.

Proposed Outcomes:

- A dynamic greenhouse energy model that quantifies the efficiency of external energy input under various climatic scenarios.
- Strategies for greenhouse temperature control that create satisfactory crop value with minimal energy cost.

Anticipated Benefits:

- Improve energy efficiency of greenhouse operations by 20 percent.
- Improve the competitive position of domestic greenhouses that are experiencing increased competition from overseas.

Project Status as of 11/15/00:

- On schedule after being granted a 3.5-month no cost term extension
- Within budget
- 90% complete overall
- Experiment set-up sensor calibration 100% complete
- Greenhouse data collection 80% complete
- Model construction calibration 50% complete
- Model validation and simulation 50% complete

A NEW GAS TURBINE ENGINE CONCEPT FOR ELECTRICITY GENERATION WITH INCREASED EFFICIENCY AND POWER

EISG Grant Number: 99-09

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: W. A. Sirignano (949) 824-3700

Organization: UC Irvine

Grant Amount: \$75,000

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of an innovative gas turbine design

that extends combustion into the turbine sections. This design process has the potential to significantly increase thermal efficiency and specific power output of gas turbines. This project will include a detailed cycle analysis to include turbine inlet temperature, pressure ratio and power distribution in the turbine stages and aerothermodynamic and combustion analysis on the flow through the turbine blades.

Proposed Outcomes:

- Optimized gas turbine design configuration.
- Identify technological obstacles that need to be overcome to advance the concept to the next level.

Anticipated Benefits:

- Increase thermal efficiency of gas turbines to 65 percent, a 15-20 percent increase over conventional engines used for electrical generation. This represents a significant increase in the percentage of the heat energy in the natural gas fuel that is converted to electrical energy.
- Increase the specific power by 100 percent over conventional engines, which allows engines to be built smaller resulting in lower capital costs.

Project Status as of 11/15/00.

- One month behind schedule. Currently one half-time post-doc and one graduate student are working on the project to accelerate the progress. May require a term extension if the schedule slip cannot be made up.
- Within budget
- 70% complete overall.
- Cycle analysis 30% complete.
- Combustion Analysis 30% complete.
- Analysis of turbine aerodynamics with combustor 0% complete.
- Identify potential issues for further research 20% complete.
- Program for performing cycle analysis is complete.

DEVELOPMENT AND CHARACTERIZATION OF IMPROVED SOLID STATE DYE-SENSITIZED NANOCRYSTALLINE SOLAR CELLS

EISG Grant Number: 99-10

PIER Area: Renewable Energy Technologies

Principal Investigator: Jin Zhang (831) 459-3776

Organization: UC Santa Cruz

Grant Amount: \$75,000

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of two innovations to reduce the cost and improve the reliability and maintainability of nanocrystalline dye-sensitized solar cells. In this type of

solar cell, sunlight is absorbed by the dye, which transfers electrons to titanium oxide particles that pass the electrons to the conductive layer on the glass. A liquid solution (electrolyte/redox mediator) is used to regenerate the dye. This project will investigate (1) use of a solid polymer film in place of the liquid electrolyte/redox mediator and (2) use of natural water-based non-toxic pigments. Four promising transparent conjugated polymers will be fabricated and tested.

Proposed Outcomes:

- Prototype nanocrystalline dye-sensitized solar cell built with a solid polymer film in place of liquid electrolyte/redox and a natural water-based pigment.
- Identify technological obstacles that need to be overcome to advance concept to the next level.

Anticipated Benefits:

- Increase the operational life of nanocrystalline dye-sensitized solar cells beyond the current limit of 7000 hours. Limitation is due to the instability of the liquid electrolyte/redox media.
- Advantage of nanocrystalline dye-sensitized solar cells is that they can be fabricated using inexpensive materials and little specialized equipment making them attractive to both industrialized and developing nations.

Project Status as of 11/15/00.

- On schedule
- Within budget
- 75% complete overall
- Selection and testing of dyes 90% complete
- Spectroscopic study of dyes and synthesis of TiO_2 95% complete
- Dynamics study of dye and polymer and TiO_2 nanoparticles 65% complete
- Fabrication of solar cells 40% complete
- Testing of solar cells and improving dye, polymer and TiO_2 properties 20% complete
- This project had a late start due to delays in equipment delivery.
- Some preliminary characterization has been performed.
- Met goal of constructing an energy band diagram for use in the understanding of the functioning of the devices.

ACTIVELY CONTROLLED JET INJECTION IN GAS TURBINE ENGINES

EISG Grant Number: 99-11

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Ann Karagozian (310) 825-5653

Organization: UC Los Angeles

Grant Amount: \$74,899

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of using actively controlled dilution air jets that deliver pulsed air perpendicular to the intake air flow in the primary zone of a gas turbine's burner to rapidly produce a lean mixture. Dilution air jets are used in gas turbines for temperature control and NO_x reduction through air-fuel mixture ratio control. This project builds upon prior work that modeled pulsed transverse jet flow, and will develop control strategies based on simulations followed by experimental validation using a bench-scale combustor.

Proposed Outcomes:

- Optimal open and closed loop control strategies for pulsed transverse dilution jets to achieve maximum reduction of NO_x emissions.
- Combustor design specifications for incorporating pulsed air jets, actuators and sensors.

Anticipated Benefits: Reduce NO_x emissions in gas turbines 50 percent by maintaining a constant lean air-fuel mixture.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 80% complete overall
- Experiments
 - Quantify penetration, mixing 60% complete
 - Input-output data 80%
 - Controller development 40% complete
 - Controller tests 20% complete
- Computations
 - 3D simulations 70% complete
 - Quantify penetration, mixing 50% complete
 - Controller development 30% complete
 - Controller tests 20% complete

OMNI SMARTPUMP

EISG Grant Number: 99-12

PIER Area: Industrial/Agriculture/Water End-Use Efficiency

Principal Investigator: B. C. MacDonald (707) 937-4352

Organization: Omni Instruments

Grant Amount: \$75,000

Grant Term: 16 Months

Project Description: The purpose of this project is to research the feasibility of using prototype, high-efficiency, variable-speed electric motors with programmable control electronics and pressure sensors to more energy efficiently provide constant optimal pressure to a closed loop drip

irrigation system. The use of a standard single speed motor running at full power wastes electrical energy when it delivers either too much or too little water pressure. This project will fabricate and bench test 3-4 prototype systems in the 2 horsepower power range that incorporate variable speed AC and DC motors, digital controllers, pump heads and external sensors. One or more of the designs will be field-tested under real world conditions.

Proposed Outcomes:

- Prototype variable speed irrigation pump optimized for drip irrigation applications.
- Compare the energy efficiency of prototype systems with conventional irrigation pumping systems.
- Identify the technological obstacles to scaling up large AC motors for variable speed operation for use in drip irrigation.

Anticipated Benefits:

- Improve the energy efficiency and cost of drip irrigation pumping systems by eliminating the need for a separate pressure tank while maintaining a constant optimal water pressure.
- Motor control technology can be scaled up to include large AC motors used in large-scale irrigation operations.

Project Status as of 11/15/00:

- Project is running 6-months behind schedule. Negotiation of term extension in progress.
- Within budget
- 60% complete overall
- Motor design 95% complete
- Microprocessor support 95% complete
- Build 4 motors 95% complete
- Design motor/pump assembly 95% complete
- Build motor/pump assembly 95% complete
- Install/test controllers 70% complete
- Write/test data acquisition 45% complete
- Bench/field testing 5% complete.
- Outdoor tests/efficiency tests 5% complete.

HIGH SPEED LIGHT ACTIVATED ON/OFF THYRISTOR

EISG Grant Number: 99-17

PIER Area: Strategic Energy Research

Principal Investigator: David Giorgi (619) 452-8787

Organization: OptiSwitch Technology

Grant Amount: \$74,900

Grant Term: 6 Months

Project Description: The purpose of this project is to research the feasibility of developing an all-light controlled on/off thyristor power switch. A thyristor is an electronic device that conducts electricity in one direction only. This

effort leverages prior development of a light activated switch capable only of turn-on that was developed for surge protection applications. This effort will add turn-off capability to the light activated switch thereby extending its potential use into a wide range of electrical devices- such as inverters, filters, pulse-width modulators, etc.- that can benefit from smaller, lighter and more efficient high-speed power switches. Preliminary physical tests will be performed to demonstrate feasibility.

Proposed Outcomes:

- Using 2D-simulation code, a mathematical model will be developed of the light controlled thyristor.
- Specifications for required laser light source.
- Process steps for device fabrication.

Anticipated Benefits:

- Increase turn-off current density capability over existing thyristor switches by a factor of four to 100 A/cm² (amps per square centimeter) while maintaining a 1µs (micro-second) turn-on time.

- This technology will enable power switches to be made smaller and lighter than existing switches, which should reduce manufacturing costs.
- Light activated switches are more reliable because they are not susceptible to faulty triggering from electrical noise.

Project Status as of 11/15/00:

- On schedule. Two-month no cost extension has been approved.
- Within budget
- 90% complete overall
- The design of the on/off thyristor is 100% complete
- Device fabrication 95% complete
- Laser design 100% complete

SOLICITATION 99-02 AWARDS

Proposals Received: 57

Passed Screening: 27

SDSU Program Administrator:

Commission Program Manager:

Approved: November 17, 1999

Grants Approved: 5 (\$374,595)

Grants Funded: 4 (\$299,595)

Hal Clark (619) 594-1158

Philip Misemer (916) 654-4552

IMPROVED OPERATIONAL TURNDOWN OF AN ULTRA-LOW EMISSION GAS TURBINE COMBUSTOR

EISG Grant Number: 99-13

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Scott Smith (408) 727-8282

Organization: Alzeta Corporation

Grant Amount: \$74,103

Grant Term: 6 Months

Project Description: The purpose of this project is to research the feasibility of a new, lean-premix gas turbine combustor design that permits precise local control of the air-to-fuel ratio which improves the operating range of the combustor and significantly reduces NO_x emissions. The project includes fabrication and testing of up to four prototype combustor configurations and the development and testing of potential control strategies.

Proposed Outcomes:

- Prototype lean-premix gas turbine combustor capable of meeting targeted emissions levels.
- Optimized fuel/air control strategy for prototype combustor.

Anticipated Benefits:

- Reduce NO_x, CO and hydrocarbon emissions in lean-premixed gas turbine combustors to 5 ppm, 10 ppm and 10 ppm, respectively.
- California relies heavily on gas turbines for electric generation and low emission gas turbines are expected to play a major role in distributed generation.

Project Status as of 11/15/00:

- On schedule. Six-month no cost term extension granted. Project delays were related to obtaining access to Honeywell's test facilities.
- Within budget
- 70% complete overall
- Prototype testing 50% complete
- John Sullivan has replaced Scott Smith as the Principal Investigator on the project
- Combustor has been redesigned and is completed
- Instrumentation changes requested by Honeywell have been completed

LOW COST MICROCHANNEL REFORMER FOR HYDROGEN PRODUCTION FROM NATURAL GAS

EISG Grant Number: 99-14

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Darby Makel (530) 895-2771

Organization: Makel Engineering, Inc.

Grant Amount: \$75,000

Grant Term: 12 Months

Project Description: The purpose of this project is to research the feasibility of fabricating prototype microchannel reformers for converting natural gas to hydrogen for use in fuel cells. Innovative fabrication strategies will be investigated and tested.

Proposed Outcomes:

- Two prototype reformers that employ different fabrication strategies.
- Performance results from prototype tests.
- Methodology for fabricating small, low-cost, scaleable, natural gas reformers.

Anticipated Benefits:

- Enable the mass production of low cost natural gas reformers, thus significantly reducing the manufacturing cost of integrated fuel cells.
- Enabling technology that would allow small residential and commercial fuel cells to operate from the abundant and inexpensive natural gas supplies in California.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 90% complete overall.
- Preliminary design 100% completed.
- Microchannel reformer design 100 % complete.
- Microchannel reformer fabrication 70% complete.
- Testing of prototype reformer 0% complete.
- Preliminary results show a methane conversion of 52% along with a hydrogen selectivity of 72%.
- Partial oxidation product analysis shows a conversion rate of 85% with a hydrogen selectivity of 79%

FEASIBILITY OF SOLAR FIRED, COMPRESSOR ASSISTED ABSORPTION CHILLERS

EISG Grant Number: 99-15

PIER Area: Building End-Use Efficiency

Principal Investigator: James Bergquam (916) 383-9425

Organization: Bergquam Energy

Grant Amount: \$75,000

Grant Term: 18 Months

Project Description: The purpose of this project is to research the feasibility of improving the performance and

reducing the cost of solar heated absorption chillers by incorporating a small vapor compressor into the design. Candidate vapor compressors will be identified and tested. This project targets small-to medium-sized commercial buildings with cooling loads up to 100 tons.

Proposed Outcomes:

- An improved design for single and double effect solar heated absorption chillers that will reduce their operating temperatures below 140 degrees F and 250 degrees F respectively.
- Identify off-the-shelf compressors or specifications for a custom compressor that will perform the required function.

Anticipated Benefits:

- Reduce the cost of the systems by eliminating the need for high pressure components that are required for systems operating above 250 degrees F.
- Reduce system payback period from 8 years to less than 5 years.

Project Status as of 11/15/00:

- On schedule
- Within budget
- 55% complete overall
- Compressor evaluation 40% complete
- Develop computer models 90% complete
- 1E chiller Compressor location 1- 100% complete
- 1E chiller Compressor location 2- 0% complete
- 2E chiller Compressor location 1- 50% complete
- 2E chiller Compressor location 2- 50% complete
- 2E chiller Compressor location 3- 50 % complete

ENERGY SHAVER – A THERMAL ENERGY STORAGE DEVICE FOR AIR CONDITIONERS

EISG Grant Number: 99-16

PIER Area: Building End-Use Efficiency

Principal Investigator: James Lester (970) 963-2517

Organization: Redstone Engineering Consulting Inc.

Grant Amount: \$74,695

Grant Term: 6 Months

Project Description: The purpose of this project is to research the feasibility of increasing the efficiency of residential air conditioners through the use of a phase change material (salt hydrate) to augment the cooling of the condensed Freon. A subscale prototype of the proposed heat exchanger will be fabricated and tested. The system will be designed as a retrofit package for existing air conditioning systems.

Proposed Outcomes:

- Mathematical model of the proposed air conditioning system to verify efficiency improvements.
- Design for an efficient, low cost heat exchanger capable of cooling the condensed Freon to 85 degrees F.

Anticipated Benefits:

- Increase the operating efficiency of residential air conditioners by up to 30 percent.
- Potential to reduce peak electric consumption in California through passive means by exploiting the large differential in day and night time temperatures that exists in the hottest regions of California and the Southwestern U.S.

Project Status as of 11/15/00:

- Project is 100% complete.
- Completed on schedule
- Completed within budget
- All tasks in Statement of Work were completed.
- Draft Final Report draft has been received and evaluated.
- Program Administrator comments back to Contractor in progress.

PROJECTS FUNDED THROUGH THE PIER PROGRAM AREAS – COMPLETED

Residential and Commercial Buildings

End-Use Energy Efficiency

EVALUATE SMALL COMMERCIAL AIR CONDITIONING UNITS FOR NORTHERN/CENTRAL CALIFORNIA

Contract #: 500-97-010

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$500,000

Contractor Project Manager: Lance Elberling
(925) 866-5519

Commission Contract Manager: R. Michael Martin
(916) 654-4039

Publication Number: P600-00-023

Project Description: This purpose of this project was to:

- Identify those technologies that can potentially improve the energy efficiency of air conditioning applications using rooftop packaged air conditioners on small commercial buildings in hot-dry climates;
- Document the actual performance of two selected technologies through laboratory testing over a range of operating conditions; and
- Provide this information to the HVAC market to encourage the adoption of appropriate technologies.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by providing electricity customers in the commercial sector with information on energy-efficient options to cool their facilities.

Proposed Outcome:

- Identify several technologies that could potentially improve the energy efficiency of air conditioning technologies with sufficient detail to enable specifiers of equipment to make good informed choices.

Actual Outcome:

- Documented several such technologies, with detailed information about performance of two such technologies at a variety of outdoor temperature and humidity conditions.
- Used evaporative condenser precoolers that resulted in greater energy savings in hot dry climates at greater initial cost and is recommended for retrofit applications.
- Used conventional design high efficiency air conditioners with dual compressors which had more modest performance improvements at a lower additional first cost and is recommended for new applications.

IMPROVE THE COST EFFECTIVENESS OF BUILDING COMMISSIONING USING NEW TECHNIQUES FOR MEASUREMENT, VERIFICATION AND ANALYSIS

Contract #: 500-97-010

Contractor and Major Subcontractors: Pacific Gas and Electric (PG&E) and Schiller Associates; ESS Engineering Inc.; and the Joint Center for Energy Management

Contract Amount: \$300,000

Contractor Project Manager: Steve Blanc (925) 866-5570

Commission Contract Manager: Joseph Wang
(916) 654-4026

Publication Number: P600-00-024

Project Description: The purpose of this project was to investigate and demonstrate cost-effective and energy-efficient methods for the commissioning of medium to large buildings that have complex mechanical, lighting, and energy management control systems. Commissioning would insure that buildings designed for maximum energy-efficiency perform as intended, thereby reducing energy costs associated with building operations.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by developing tools to analyze, and guarantee, the performance of energy-efficiency measures.

Proposed Outcomes: A major obstacle to wide-spread adoption of building commissioning is cost. This project created commissioning techniques more effective and less costly to implement. These techniques were tested in a laboratory and a demonstration site to evaluate their performance. The system included high-quality sensors, a knowledge base to identify system failure, automated communications and data management and data visualization to diagnose building energy performance problems. In addition, the project developed:

- Specifications for a building fault detection and diagnostics technique that would provide a platform for further commercial development and provide information needed to automate the diagnosis of building energy performance problems;
- A commissioning tool which would focus on the identification of minimum historical data requirements

necessary to accurately predict cooling system performance in a typical commercial building; and

- A measurement and verification tool that would allow users to evaluate different measurement scenarios to determine cost effectiveness for specific energy-efficiency measure.

Actual Outcomes:

- Developed a model-independent, fault detection and diagnostics for variable air volume terminal units. This commissioning tool is based on the use of a residual approach to develop fault detection and diagnostics tool preprocessors. This avoids the traditional use of model based approach requiring that a tool be calibrated using large amount of historical data.
- Developed a first principles model for integrated cooling systems. This tool focuses on the identification of the minimum historical data requirements necessary to accurately predict cooling system performance in a typical commercial building.
- Developed a building automation control network (BACnet)-based control system driver to facilitate fault detection and diagnostics (FDD) in open architecture energy management control systems. This tool is a generic communications interface for controls systems employing BACnet gateway open protocols. This allows building operators access building data with any building control systems.
- Developed a measurement and verification value tool that is a data base-driven program that allows the user to evaluate different measurement and verification scenarios to determine cost and saving uncertainty for specific energy efficiency measures.

IMPROVE THE COST EFFECTIVENESS OF BUILDING CONTROL SYSTEMS SENSING AND DATA COLLECTION

Contract #: 500-97-010

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$250,000

Contractor Project Manager: Steve Blanc (925) 866-5570

Commission Contract Manager: Joseph Wang (916) 654-4026

Publication Number: P600-00-025

Project Description: The purpose of this project was to investigate methods to reduce the costs of current energy-management systems, such as low-cost building control systems and sensors. Energy management systems allow utility customers to monitor and control their energy consumption and improve the energy-efficiency of the whole building.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by providing utility customers with tools that could help reduce their energy consumption.

Proposed Outcomes:

- Develop a method for determining the accuracy and storage frequency needed for various data acquisition functions in commercial HVAC systems, and
- Specify the use of economics (costs versus benefits) and operating needs to determine accuracy and storage frequency for data collected from commercial HVAC systems.

Actual Outcomes:

- PG&E developed a method for determining the accuracy and storage frequency required for various data acquisition functions in commercial HVAC systems.
- PG&E demonstrated the method on an example building under two different weather profiles (focusing on the air-handling equipment and chilled water temperature) and showed the potential benefits when more accurate equipment and better diagnostic techniques are used.
- PG&E repeated the analysis on several other building types and sizes using a different energy simulation model. The result is a range of recommended measurements, storage frequencies, and potential energy savings for buildings with different annual energy uses.

RESIDENTIAL THERMAL DISTRIBUTION SYSTEMS

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute for Energy Efficiency; Lawrence Berkeley National Laboratory; ConSol Consulting

Contract Amount: \$400,000

Contractor Project Manager: Karl Brown (510) 642-7545

Commission Contract Manager: Dale Trenchel (916) 654-4098

Publication Number: P600-00-002

Project Description: The purpose of this project was to develop new knowledge and prototype technologies that would improve the energy-efficiency and performance of heating, ventilation and air conditioning (HVAC) equipment in residential buildings. The work included developing and testing the effectiveness and durability of duct sealant technologies for use in residential buildings. New methods of measuring duct leakage were evaluated, and interactions between equipment sizing and the effectiveness of the distribution system to deliver cooling throughout a home were analyzed. A significant issue investigated was the ability of downsized equipment and

good distribution systems to deliver the same cooling benefits as larger, typical HVAC systems, but at a lower cost to the consumer.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by providing information, tools and products to reduce HVAC energy consumption in residential buildings. Specifically, this project will develop new procedures to evaluate the longevity of sealants used on residential HVAC ducts and new test methods for measuring energy losses through duct leakage. These results make possible the reduction of electricity for home heating and cooling use in residential HVAC systems through better duct sealing measures, reduced equipment sizing and improved diagnostics.

Proposed Outcomes:

- Improve duct leakage test methods.
- Update the American Society for Testing and Materials (ASTM) Standard E1554 – *Determining External Air Leakage of Air Distribution Systems by Fan Pressurization*.
- Develop and introduce a draft ASTM standard for longevity testing of duct sealants.
- Measure the performance of residential cooling equipment and associated distribution systems.
- Compare the REGCAP simulation model to the measured field data.
- Provide technical support to the Energy Commission for updating the *Low-Rise Residential Alternative Calculation Method Approval Manual for 1998 Energy Efficiency Standards for Low-Rise Residential Buildings (CEC 1999) and Procedures for HVAC System Design and Installation (for HERS)*.
- Support ASHRAE, ASTM and U.S. EPA duct leakage research and interface with projects funded by other agencies.

Actual Outcomes:

- This investigation yielded a new duct leakage test called DeltaQ.
- The existing ASTM Standard (E1554) for measuring duct leakage has been rewritten and submitted to the ASTM standards review process.
- A draft ASTM standard for longevity testing of duct sealants was developed. A draft was submitted to ASTM subcommittee E06.41 for balloting and comment. The comments on the draft resulted in changes to the test method and apparatus. A new test apparatus was constructed with funding from the U.S. DOE.
- Simulations of summer temperature pulldown time have shown that duct system improvements can be combined with equipment downsizing to save first cost, energy

consumption, and peak power and still provide equivalent or superior comfort.

- Air conditioner name plate capacity ratings alone are a poor indicator of how much cooling will actually be delivered to the conditioned space. Duct system efficiency can have as large an impact on performance as variations in Seasonal Energy Efficiency Ratio (SEER). Installing high SEER units can reduce energy consumption with no apparent drawbacks.
- Duct efficiency calculations are included in the *Low-Rise Residential Alternative Calculation Method Approval Manual for 1998 Energy Efficiency Standards for Low-Rise Residential Buildings* (CEC 1999).
- Procedures for HVAC System Design and Installation (for Home Energy Raters) have been updated.
- Field-testing has shown that standard flowhoods can be poor for measuring residential register flows.

COMMERCIAL THERMAL DISTRIBUTION SYSTEMS

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute of Energy Efficiency (CIEE) and Lawrence Berkeley National Laboratory (LBNL)

Contract Amount: \$400,000

Contractor Project Manager: Karl Brown (510) 643-1617

Commission Contract Manager: Mazi Shirakh (916) 654-3839

Publication Number: P600-00-004

Project Description: The purpose of this project was to develop information and products that would improve the energy-efficiency and performance of heating, ventilation and air conditioning (HVAC) equipment in commercial buildings. This project assessed the performance of air-duct systems in California's commercial buildings, developed and tested duct-sealant and duct-encapsulation technologies specifically for applications in commercial buildings, and developed tools to diagnose the energy-performance of commercial building fan systems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing peak demand and improving load factor, leading to reduced infrastructure costs and system reliability risks;
- Improving the energy cost/value of California's electricity by improving thermal performance of the commercial thermal distribution systems. Current data suggests that leakage in commercial thermal distribution systems is in excess of 20 percent, with additional excess energy use caused by fan system problems; and
- Improving the environmental and public health costs/risks of California's electricity by improving indoor air quality through improved control of air flows and duct encapsulation technology.

Proposed Outcomes:

- Advance knowledge about performance and losses for commercial building thermal distribution systems.
- Evaluate the potential for reducing thermal losses through duct sealing, duct insulation, and improved equipment sizing.
- Advances in innovative techniques for sealing ducts and encapsulating internal duct insulation.
- Advances in protocols and techniques for testing, analyzing and diagnosing energy-related problems in large commercial building fan systems.

Actual Outcomes:

- Identified significant duct leakage in large commercial buildings, with large associated energy losses.
- Confirmed significant potential energy savings from duct sealing in large commercial buildings and identified building model enhancements that will allow incorporation of duct performance improvements in building energy standards.
- Improved prototype equipment and field experience for duct sealing and encapsulation technology.
- Made advances in tracer gas measurement techniques and refined protocols for diagnosing energy losses in large building fan systems.

DIAGNOSTICS FOR BUILDING COMMISSIONING AND OPERATIONS**Contract #:** 500-97-013**Contractor and Major Subcontractors:** California Institute for Energy Efficiency (CIEE) and University of San Diego; SuperSymmetry; Stanford University and Jones Lang Wootten: California Inc.**Contract Amount:** \$350,000**Contractor Project Manager:** Carl Blumstein
(510) 642-9590 ext.202**Commission Contract Manager:** Joseph Wang
(916) 654-4026**Publication Number:** P600-00-005

Project Description: The purpose of this project was to demonstrate a system that allows building occupants to monitor the energy use within their building, so they may determine if the building is performing at its optimum energy-efficiency level. This system will permit building occupants to improve the energy-efficiency of their buildings by facilitating the identification of energy performance problems.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by helping customers optimize their building systems to perform at their peak energy efficiency.

Proposed Outcomes: This project was to demonstrate an advanced operator information, monitoring and diagnostics system (IMDS) for whole-building commissioning and operations. The system and project objectives included:

- High-quality sensors.
- Knowledge base to identify system failure.
- Automated communications and data management.
- Data visualization to diagnose building energy performance problems.
- Evaluating the energy savings and other non-energy benefits of IMDS use. The objective is to reduce total energy use and energy cost by 15 percent without sacrificing any other building services or performance issues.
- Developing and demonstrating techniques to automate fault detection and diagnosis using a steady-state chiller model and evolutionary programming for self-learning systems.
- Evaluating the decision making and technology adoption processes in the commercial buildings sector.

Actual Outcomes:

- LBNL successfully demonstrated that the IMDS is very useful in evaluating the building's performance. The building operators perceive significant improvements in the performance of the building. These include improvements in control, reduced comfort complaints, and the identification of significant energy savings. Even more significant is that the IMDS has been useful in identifying an ongoing set of problems at the building that are related to problems inherent in the control systems.
- LBNL developed a prototype stand-alone chiller data analysis tool was developed to provide the operations staff with additional diagnostic capabilities beyond the IMDS. However, neither the chiller diagnostic tools nor the utilization techniques are mature at this point.

BUILDING DESIGN ADVISOR**Contract #:** 500-97-013**Contractor:** California Institute for Energy Efficiency (CIEE)**Contract Amount:** \$350,000**Contractor Project Manager:** Konstantinos Papamichael,
(510) 486-6854**CIEE Project Manager:** Carl Blumstein (510) 642-9590
ext.202**Commission Contract Manager:** Tav Commins
(916) 653-1598**Publication Number:** P600-00-008

Project Description: This project updated the Building Design Advisor (BDA), a Windows-based computer program that facilitates decision making through integrated

use of multiple analysis tools and databases. This tool, when completed, will enable building designers to consider various energy efficiency options during the design stage of new buildings, when energy efficiency measures are typically more cost effective. The main deliverable for this project was to integrate DOE-2 into the tool. DOE-2 is a building energy simulation program that is the industry standard for producing detailed and accurate energy performance simulations.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective.

Proposed Outcomes:

- Bring the initial BDA software from an unstable, incomplete Beta release to a robust 1.0 version for distribution to academia and the building industry for evaluation and feedback.
- Develop an updated 2.0 version with links to DOE-2. This will demonstrate the expandability of the BDA software to include links to simulation tools already accepted and trusted by the building industry and make the BDA more appealing for use in actual projects.
- Elicit industry feedback to identify industry needs and desires, towards BDA versions that will be appropriate for use in actual projects.
- Prepare a commercialization strategy for widespread distribution of the software with proper user support.
- Initiate developing a BDA-based Issue Based Information System (IBIS) that will facilitate the use of the BDA as a collaborative, concurrent design tool, and greatly enhance developing links to tools that address the whole building life cycle, from design through construction and commissioning, to operation and eventual demolition.

Actual Outcomes:

- The BDA 1.0 has been in distribution since January 1999, free of charge through the Internet. To date, more than 450 reviewers have downloaded the software from the project's Web site. Approximately 150 reviewers are from academia (professors and students) and 300 are from the building industry (architects, engineers, energy consultants, etc.).
- Beta releases of BDA 2.0, with links to DOE-2, were used in workshops with architects and engineers in the San Francisco, Los Angeles, and Sacramento areas. Useful comments were elicited through extensive interactions between the software developers and the building industry participants. Comments and suggestions were organized and prioritized based on workshop participants input.

- The response to the BDA concept has been enthusiastic and has resulted in very useful feedback on the specific needs of building design professionals. Several university professors plan to use the BDA software in relevant architectural and engineering courses.
- A commercialization report was prepared.
- The design of the BDA-based IBIS was completed, with potential use scenarios and graphical user interface elements for implementation in future versions of the BDA software.

ALTERNATIVES TO COMPRESSOR COOLING

Contract #: 500-97-013

Contractor: California Institute for Energy Efficiency (CIEE)

Contract Amount: \$350,000

Contractor Project Manager: Karl Brown (510) 486-5338

Commission Contract Manager: Randel Riedel (916) 654-4109

Publication Number: P600-00-003

Project Description: The purpose of this project was to develop and evaluate house designs capable of providing comfort in California transition climates without the use of conventional compressor-based cooling. Compressor-based cooling is growing rapidly in transition climate zones inland from major California coastal urban centers. However, the low hours of air conditioning use in these areas create an extremely poor load factor with a substantial adverse effect on costs of service and electric system operations.

Compressor-less cooling will result in energy and peak demand savings in the warmer climate zones in California. With the highest practical market penetration, the potential avoided increase in new electric demand is estimated to be 0.5 Watt per square foot of new house area averaged across all new residential construction. The equivalent potential in retrofit is estimated to be one Gigawatt in California. Load factors would be improved with a substantial increase in system reliability and decrease in cost of service. In addition, air-conditioning system size will be reduced in more severe climates through the adoption of project design concepts.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing peak electrical demand created by compressor-based air conditioning; and
- Improving the energy cost/value of California's electricity by reducing energy use and costs created by residential space cooling during summer "heat storms."

Proposed Outcomes:

- Evaluate pilot houses and/or subdivisions using project-developed house designs.
- Develop a prototype cost/capability-optimized alternative cooling system controller.
- Provide technology transfer through design information dissemination, assistance, and evaluation.
- Promote the project with design competitions.
- Develop applications information to assist market transformation programs.

Actual Outcomes:

Evaluate pilot houses and/or subdivisions using project develop house designs.

- A Northern California prototype house design was developed.
- A Southern California prototype house was modified and a variation with street access to the garage was designed. Builders and developers in California were solicited to initiate a pilot house or subdivision program. Everyone contacted was interested in the prototype concepts and designs, but were unwilling or unable to commit to building a pilot project.
- An expanded definition of "comfort" and the impact of Time of Use charges were both found to support the technology concept of the compressorless cooling design.
- The Northern California prototype house performance simulation was not completed so applications and sizing information is based on the results from the Southern California house. The Northern California house is expected to perform even better.
- Performance simulations demonstrated that compressorless technologies will not maintain comfort in the Southern California prototype house in all California transitional climates. However, a substantially downsized compressor (1.5 tons) operated in concert with the night ventilation and house design will maintain comfort in all transitional climate areas and in all but the most severe hotter inland climates. The performance simulations for this phase of the ACC project have been re-checked and are correct.
- Appraisers indicated that the disadvantages of a smaller compressor or no compressor would be offset by the superior construction of this particular type of residence. However, they would prefer to make their determination of energy tradeoffs based on an existing model for comparison with standard designs and construction.

Develop a prototype cost/capability-optimized alternative cooling system controller.

- A prototype low energy cooling control system to enable operation of the house for night ventilation was developed and tested in two houses. The result was a demonstrated reduction in compressor cooling use while comfort was maintained in a moderately hot climate.

- Based on occupant interviews, the user interface was successfully used by the occupants to maintain comfort and reduce compressor use during an overheated period.
- Occupants were able to operate the controller effectively although they did not necessarily understand the technical details of the mechanical system.
- Feedback from the controller web page simulation confirmed the usefulness of the comfort range strategy in the interface design and identified modifications to the interface that will be revised in the next phase.

Provide technology transfer through design information dissemination, assistance, and evaluation.

- The PIER research team presented the house designs, control design and program concepts to many individual builders, developers, architects and owners.
- The house designs were presented in more formal venues including: Los Angeles Depart of Water and Power in regard to Playa Vista Development, the San Diego Regional Energy Office, LBNL Noon Lecture Series, CIEE Tri-annual Review, NAHB Green Building Conference, Green Building Challenge Conference, poster session at the PIER Conference "Energy Innovations '99", and to the following individuals in Washington, D.C.: Rich Karney (DOE), Mark Ginsberg (FEMP Director), George James (Building America), Larry Zarker (PATH), Sam Raskin (ENERGYSTAR Homes, EPA), Mark Nowak (NAHB Research Center).
- The following publications were produced: *Smart Thinking About Smart Houses, and Ventilation Cooling Without Losing Control.*

Promote the project with design competitions.

- In 1999, a professional slide show and script on the concepts and prototype designs were developed and presented during the "Gold Nugget Awards" held at the annual Western Building Show.
- Two custom homes with low energy cooling, shading, thermal mass and night ventilation received the "1999 Summer Performance Awards".

Develop applications information to assist market transformation programs. Current trends in the residential industry which are complementary with compressorless strategies provide opportunities for market adoption. These include interest in "green buildings", "new urbanism", "concern for indoor air quality, health and environment", Energy Efficient Mortgages, and the embracing of "quality" as a marketing strategy.

HIGH-EFFICIENCY LIGHTING TORCHIERES

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute of Energy Efficiency (CIEE) and Lawrence

Berkeley National Laboratory(LBNL)

Contract Amount: \$90,000

Contractor Project Manager: Carl Blumstein
(510) 642-9590 ext.202

Commission Contract Manager: Mazi Shirakh
(916) 654-3839

Publication Number: P600-00-006

Project Description: This purpose of this project was to develop portable, high-efficiency, indirect torchiere fixtures that would use one of the next generation high-efficacy electrodeless or electroded fluorescent lamps. These fixtures are targeted at the commercial office interiors where there is a demand for high color quality and low-glare portable lighting. This proposed effort was a first step in the development and demonstration of new office torchiere lighting systems. Wide adoption of the technology developed in this project would significantly increase the penetration of high-efficiency fixtures in commercial interiors.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by improving the efficacy of the very popular torchieres. Incandescent torchieres are very inefficient and present a fire hazard. The proposed advanced torchieres reduce electrical consumption by 75 percent.

Proposed Outcomes:

- Produce prototype fixtures that exploit the properties of the next generation of high efficiency advanced fluorescent lamps and advanced optical reflectors.
- The prototypes were expected to have high color quality and low glare suitable for use in commercial office spaces

Actual Outcomes:

- The LBNL contract discusses high efficiency lamps with efficacies in the range of 83 to 100 lumens per watts. The actual outcome was lamps with efficacies in the 72 to 79 lumens per watt. The commercially available lamps currently have efficacies in the 55 to 69 lumens per watt.
- The proposed lamps have color temperatures and color rendering indexes that are comparable or superior to what is commercially available.
- LBNL also experimented with different types of optical reflecting materials, determining that white paint is the most practical due to cost considerations.
- The retail costs are expected to be around \$60-\$70 a unit which is competitive with what is available now (which is around \$50-\$60 for high-end products).
- Currently there are no torchieres with the upright/downlight components and with the range of efficacies discussed above.

CIEE COLLABORATIVE PROGRAM PLANNING AND MANAGEMENT

Contract #: 500-97-013

Contractor: California Institute of Energy Efficiency (CIEE)

Contract Amount: \$600,000

Contractor Project Manager: Jim Cole (510) 486-4123

Commission Contract Manager: Gary Klein
(916) 653-8555

Publication Number: P600-00-001

Project Description: The purpose of this project was to coordinate the efforts undertaken in the eight CIEE Transition solicitation projects. The project was to provide planning, funding, management and technology transfer activities for these projects. CIEE was the primary link between the Commission's contract managers and the principal investigators. CIEE was to ensure that the administrative and reporting requirements of each project were met.

CIEE was scheduled to release a Request for Proposals (RFP) for the first phase of a new multi-year project known as the Market Transformation Research: New Commercial Buildings Project. This new project was to have been managed by CIEE. CIEE was to maintain an Internet web site that contains information on the Commission-funded Transition Solicitation projects as well as integrate technology transfer activities into the transition project activities.

Proposed Outcomes:

- Manage the research and development of the new end-use efficiency technologies emphasized in CIEE projects.
- Coordinate with the research teams, the CIEE Research Board and other Sponsor representatives in exploring the initial market applications of the new energy efficiency technologies.
- Conduct a review of the CIEE R&D program by independent peer review panel.

Actual Outcomes:

- Final report for each project produced.
- CIEE recommended the establishment of a statewide, coordinated Emerging Technologies Initiative to the California Board for Energy Efficiency (CBEE) and the California Public utilities Commission (CPUC) in June and July of 1999.
- CIEE, in collaboration with Energy Commission staff and CIEE Sponsor representatives, prepared and issued a Request for Proposals (RFP) to select a research team and detailed research plan for the CIEE multiyear project: Market Connections for New Commercial Building Technologies.

- CIEE collaborated with Southern California Gas and other CIEE Sponsor representatives in planning and funding two public interest R&D projects involving low NO_x, energy efficient combustion of natural gas in industrial, commercial and other market applications.
- Independent peer review conducted in April 1999, concluded that the overall quality of CIEE's R&D program was outstanding.

TARGET 1 RESIDENTIAL HEAT PUMP TECHNOLOGY

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; D.W. Abrams, P.E. & Associates; P.C.; OG&E Electric Services Company; Oregon Department of Energy; Saturn Resource Management; Southern California Edison Co.

CEC Project Amount: 1999: \$293,697

Match Funding: 1999: \$1,129,818

Contractor Project Manager: Carl Hiller (530) 758-3035

Commission Project Manager: Bill Pennington

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to support EPRI's continuing development of high-performance (energy efficient) heat pumps and their efforts to deliver quality data and services to invigorate the market. Working with manufacturers and research partners, EPRI is supporting production of climate-wise air and geothermal heat pumps, demonstrating heat pump applications, verifying performance and energy efficiency, and pursuing refinements to the "Insider" heat pump, a compact unit for multifamily and manufactured housing. This target also delivers products on duct system design and duct sealing technology to further reduce energy waste, and collaboration on a national technician certification program to address installation and customer satisfaction issues.

EPRI's collaborative program impacts technology development and heat pump infrastructure nationally. This, in turn, benefits California users to ensure a continued positive market environment for residential heat pumps. The Commission will receive technical information and persuasive promotional materials for local educational activities to stimulate residential customer's interest.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and enhancing the performance and efficiency of residential heat pump technology to reduce the energy needs for space heating and cooling applications; and

- Improving the environmental and public health costs/risks of California's electricity by reducing energy use, which in turn decreases power generation emissions, and by supporting the changeover from ozone depleting refrigerants to Zero Ozone Depletion Potential (ZODP) fluids.

Proposed Outcomes:

1. Provide tools to increase the use of Zero Ozone Depletion Potential (ZODP) Refrigerants.
2. Provide tools to increase the potential for the use of Air-Source Heat Pumps.
3. Provide information to support market-ready enhanced, integrated heat pumps.
4. Develop a Technician Certification program to improve the likelihood of proper heat pump selection and proper installation.
5. Supply information to increase the potential for use of Ground-Source Heat Pumps (GHP).
6. Compile information to increase the potential for use of Thermal Distribution Systems Development and Applications.
7. Conduct a Tailored Collaboration entitled "Research on Heat Pump Performance Maps for Incorporation into Building Energy Analysis Calculation Methods" to develop improved calculation methods that permit more accurate comparison of standard air-source heat pumps and air conditioners with ground-source heat pumps.

Actual Outcomes:

1. Software and information were provided on the performance of zero ozone depletion potential refrigerants.
2. Air-source heat pumps.
 - Version 1.0 was released of EPRI's ESPRE for Windows, which can be used to analyze building energy use as a function of technology.
 - Version 3.0 was released of EPRI's Residential Desk Book, which offers a compendium of information of end-use residential technologies.
 - Brochures were published on dual fuel heating and cooling, sealing heating and cooling systems, and repairing leaky ducts.
 - A newsletter was published on heat pump developments, issues, and markets.
3. Integrated heat pumps.
 - Support was provided to the manufacturer of the PowerMiser integrated heat pump.
 - A brochure was published on marketing integrated heat pumps
 - A brochure was published on the Insider integrated heat pump.
4. EPRI assisted in the development of a comprehensive technician certification program, which merged the testing and certification programs of NATE, ACCA, and RSES.

5. Ground-source heat pumps (GSHPs).
 - A design and installation planning guide was published for GSHPs.
 - A directory was published of GSHP manufacturers and equipment.
 - EPRI hosted the 1999 GeoExchange Industry Conference and Exposition in Sacramento in September 1999.
6. A brochure was published on optimizing thermal distribution systems.
7. Detailed performance map data were collected on both air- and ground-source heat pumps for use in an upgraded analytical procedure to be used in California Title 24 residential building energy compliance evaluations. Several thousand performance maps were obtained, and recommendations were made on analytical procedure modifications.

Status: The Commission's participation in this target ended as of December 31, 1999. Participation in the tailored collaboration ended December 2000.

TARGET 11 COMMERCIAL BUILDING LIGHTING

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; University of Wisconsin; Polytechnic University of New York; Los Alamos National Laboratory; National Institute of Standards and Technology; Lighting Research Center; BKI, Inc.; New Buildings Institute; Pacific Consulting Services; Osram-Sylvania, Inc.; Lighting Ideas, Inc.; Gough & Associates, Inc.; National Council on Quantification for Lighting Professionals; Illumination Engineering Society of North America

CEC Project Amount: 1999: \$ 24,000

Match Funding: 1999: \$204,323

Contractor Project Manager: John Kesselring
(650) 855-2902

Commission Project Manager:

Gary Flamm (916) 654-2817

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to guide California ratepayers to new lighting systems that reduce their energy bills and boost worker productivity and comfort. EPRI's Lighting Information Office (LIO) provides world-class, up-to-date information on lighting technologies and cost-effective training and information services. LIO insights are captured in customer-friendly formats that the Energy Commission can easily customize for delivery to California ratepayers. EPRI has produced an array of system design and analysis software that Commission staff can use in calculating the performance, costs, and benefits

of lighting options for any customer's application. In addition, EPRI via this Target is directing collaborative research to define the relationship between lighting and productivity.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficacy of lighting sources with advanced light source technology.

Proposed Outcomes:

1. Provide advanced lighting technologies information.
2. Provide analytical tools to assess advanced lighting technology options.
3. Advance the understanding of lighting benefits and accelerate the development of advanced, high-efficiency lighting products.

Actual Outcomes:

1. Technology information.
 - New information was provided through the Lighting Information Office on energy-efficient lighting—including residential compact fluorescent lighting, electronic ballasts, LED exit signs, and outdoor luminaires. This information can be used to upgrade lighting in all California state office buildings and to consider for new standards legislation.
 - Two training sessions were offered that addressed the unique design, cost, and customer applications issues posed by new advanced lighting products.
2. Analytical tools.
 - The Commercial Desk Book software package was provided. This package provides technical, marketing, and regulatory information on lighting systems and allows users to calculate and compare annual operating costs of different technologies.
 - Software support was provided for LightPAD (the EPRI lighting audit software), PowerDOE, Daylight Analyzer, and other products.
3. Understanding of lighting benefits, and development of advanced, high-efficiency lighting products.
 - A report described the effects of three different lighting configurations on office workers doing data entry tasks.
 - A publication was provided that reported on significant advances in scotopic vision. Information on the impacts of lighting on human performance can be used to ascertain whether proper light levels are being implemented in office work, and to help ensure that reduced lighting levels do not compromise human performance.
 - Research briefs were presented on basic research related to Hg-Ar and Ba as discharge light sources, which could double the energy efficiency of today's fluorescent lamps.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

COMMERCIAL COOLING AND HEATING PUMP APPLICATIONS (#1417)

Contract #: 100-98-003 (#5)

Contractor and Major Subcontractors: Gas Technology Institute (GTI), Hybrid Gas Engine/Electric Motor/Chiller – Alturdyne (San Diego, California), Advanced Absorption Cooling – CoolTec, Gas Turbine Inlet Cooling – Polar Works, Commercial Heat Pump – Goettl, Spray Absorption Technology – GTI Performing Laboratories

Contract Amount: 1999: \$45,600
2000: \$31,500

Contractor Project Manager: Ron Edelstein
(847) 768-0898

Commission Contract Manager: Brad Meister
(916) 654-4739

Project Description: The purpose of this project is to develop and deploy cost-effective cooling products and maximize their market adoption and use. Major activities under this project include:

- improved chiller performance;
- updated state-of-the-art technologies for existing absorption chillers;
- low-cost, engine-driven heat pump technologies for commercial applications;
- hybrid chiller design protocols; and
- research results of advanced turbine component tests.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing cooling technologies that will reduce electricity consumption by California energy consumers.

Proposed Outcomes:

1. Hybrid Gas Engine/Electric Motor/Chiller: Development of a Hybrid Gas Engine/Electric Motor/Chiller capable of being run on either natural gas or electricity offering the customer the option of selecting their energy source. The second phase of the project will include reversing the motor to add generation capacity to the chiller for further electricity peak shaving flexibility.
2. Advanced Absorption Cooling: Develop and test a five-ton absorption-based natural gas cooling technology capable of reducing electricity demand by 5-kW per household or commercial application.
3. Gas Turbine Inlet Cooling: Novel approach to using natural gas cooling to cool the inlet air to gas turbines, increasing the available power output during hot weather. The technology envisioned will allow inlet air temperature

to be dropped far lower than with conventional systems without causing turbine damage and therefore will produce significantly greater power from an existing turbine set than available with any other system. The overall effect is an increase in efficiency and a reduction in the capital cost of a turbine generating system.

4. Commercial Heat Pump: Development of a 15-30 refrigeration tons (RT) natural gas engine-driven heat pump with Goettl Air Conditioning.
5. Spray Absorption Technology: Development of technical data on spray distribution of solution for absorption chillers to ascertain technical feasibility.

Actual Outcomes:

1. Hybrid Gas Engine/Electric Motor/Chiller: The initial Hybrid Engine/Electric/Chiller product is now commercially available. The prototype 100-ton unit has been built with the motor to add generation capacity to the chiller for further peak shaving flexibility.
2. Advanced Absorption Cooling: Two laboratory prototypes were built and durability tested in the lab. Testing of one prototype in a certified test chamber has now been completed. The first test unit has been shipped to Brooklyn Union (now Keyspan Energy) for testing this summer.
3. Gas Turbine Inlet Cooling: The initial desiccant dehumidification alpha test was successfully completed. Discussions were conducted with a major turbine manufacturer. However, the manufacturer did not decide to pursue the Polar Works approach due to the results of the modeling effort. This work has now been wrapped up and this contract is being closed out.
4. Commercial Heat Pump: The development of 15, 20, 25, and 30 RT units has been completed, and those units are now commercially available.
5. Spray Absorption Technology: The project has been completed, and results presented to Trane. After testing the concept, Trane decided not to move forward with this concept.

Project Status: Efforts continue as planned for the Hybrid Gas Engine/Electric Motor/Chiller and Advanced Absorption Cooling projects. The Commercial Heat Pump project was successfully completed. Technical efforts were completed on the Gas Turbine Inlet Cooling and Spray Absorption Technology projects, but work has now been discontinued because manufacturers decided not to pursue the technologies.

Industrial / Agricultural / Water End-Use Energy Efficiency

INTEGRATED AGRICULTURE TECHNOLOGY

Contract #: 500-97-012

Contractor and Major Subcontractors: Edison Technology Solutions

Contract Amount: \$320,000

Contractor Project Manager: Lory Larson

Commission Contract Manager: Ricardo Amon

Publication Number: P600-00-012

Project Description: This project demonstrated the use of ozone as a substitute soil fumigant; ozone as an alternative to aqueous toxic chemicals for fungi control in fruit packing plants; low-temperature, controlled-ventilation in storage facilities; innovative manure treatment technologies; and irrigation scheduling systems.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficiency of emerging electrotechnology applications in agriculture and improving the environment, and
- Improving the public health costs/risks of California's electricity by replacing toxic chemicals with cleaner electrotechnologies in the fruit industry.

Proposed Outcomes:

- Determine the effectiveness of ozone as a preplant soil fumigant to destroy a variety of soil-borne microorganisms.
- Determine the effectiveness of ozone as a disinfectant and fungicide in aqueous solutions used for fruit storage and packaging operations and ozone treatment for discharge water quality purposes.
- Determine the effectiveness of ozone as a post-harvest fumigant to control insect infestation of fresh and dried fruits and vegetables.
- Demonstrate the viability and practicality of a low-cost, temperature-controlled storage facility to inhibit insect infestation of stored fruit. Test the effectiveness of plastic film bin liners to control insects in stored prunes. Develop baseline data on Indianmeal moth populations near drying and storage facilities.
- Determine the functionality of an innovative biological treatment device to manage the disposal of liquefied animal wastes.

Actual Outcomes:

- Ozone treatment demonstrated substantial improvements and crop yield or plant vigor compared to untreated controls in all crops tested, except peaches. Soil treatment with ozone decreased soil pathogens and increased nutrient availability.
- From 95 to 100 percent of all 8 fungi tested were killed in 2 minutes of contact time with the ozone treatment. None survived 3 minutes of contact. Higher doses of ozone were required to kill pathogens on fruit surfaces than those needed to kill spores in water. Ozone significantly reduced gray mold incidence on table grapes, but its efficacy was irregular. Ozone was inferior to sodium hypochlorite, sodium bicarbonate, and ethanol as a fungicide. The control of pathogens inoculated into wounds in citrus fruit failed even after prolonged treatment with very high ozone concentrations in water.
- Table grapes, citrus fruit, and strawberries were not visibly injured by the ozone treatments evaluated. In strawberry wash water, ozonation for 3 hours greatly reduced microbe populations, moderately reduced biochemical oxygen demand, chemical oxygen demand, and suspended solids; did not reduce total organic carbon; and increased total dissolved solids.
- Four to 6 hours of exposure to ozone concentrations of 300 to 500 parts per million were needed to kill Indianmeal moth larvae and diapausing codling moths. Chambers designed for ozone fumigation will need to be made of materials that can withstand the corrosive action of continuous exposure to high concentrations of ozone. Therefore, results of this first phase are preliminary and more research is required.
- The controlled ventilation and evaporative cooling system was too expensive to install, considering it would only provide safe storage temperatures for 7 months of the year. Prune quality was determined to be excellent after 1 year in storage in plastic bags. Moisture content of the prunes did not change during storage, and the fruit was exceptionally free of sugaring and mold compared to fruit stored conventionally. Bins with liners must be stored in an environment that prevents significant diurnal temperature fluctuations. Baseline data collected indicated that Indianmeal moth is the species of most concern for prune storage. The liner storage system will work well only if fruit is virtually free of infestation before being placed in the liners.

- The sequencing batch reactor was determined an effective biological reactor for treating dairy wastewater. A two-stage sequencing batch reactor system is recommended over a single-stage system if nitrification is desired. The two-stage system was capable of achieving near-complete conversion of ammonia to nitrite and nitrate in the dairy wastewater.

LOW DROSS ALUMINUM MELTER PROJECT

Contract #: 500-97-012

Contractor and Major Subcontractors: Edison Technology Solutions (ETS) and TIMCO, Division of TST, Inc.; Paul Wurth, Inc.

Contract Amount: \$450,000

Match Funding: \$2,650,000

Southern California Edison: \$1,950,000

EPRI: \$300,000

DOE NICE3: \$400,000

Contractor Project Manager: Mazen Sadeq
(626) 815-0513

Commission Contract Manager: Dennis K. Fukumoto
(916) 653-6222

Publication Number: P600-00-011

Project Description: The purpose of this project was the demonstration of an advanced DC-Arc Plasma furnace designed to melt aluminum scrap material for the reuse market within a controlled, oxygen-starved environment that prevents the formation of aluminum oxide (dross) and reduces the volume of process waste material.

This project supports the PIER Program objectives of:

- Improving the energy cost and value of California's electricity by demonstrating a technology that increases energy efficiency by 80 percent for recovering scrap aluminum for reuse; and
- Improving the environmental and public health costs/risks of California's electricity by demonstrating a technology that yields the following advantages over gas-fired reverberatory furnaces.

Proposed Outcomes: The objective of this project was to design, fabricate, and place into operation a five-ton DC Plasma Arc melter that meets typical commercial melting requirements of the scrap aluminum recycling industry by:

- Upgrading the one-ton Wabash unit and apply various lessons and design improvements gained from the experimental operation of that unit.
- Demonstrating the commercial viability of the DC Plasma-Arc melting technology for the aluminum reprocessing industry.
- Design and build a 5-ton unit at a commercial site.

Actual Outcomes: Design requirements for modification of the Wabash unit were prepared by the Technical Team under the direction of ETS. The Wabash upgrade activities included:

- Tightening of furnace seals to lower dross formation.
- Design of a mechanical stirring capability.
- Relocation of furnace electrodes to increase furnace efficiency.
- Improve furnace feed system to increase throughput and reliability.
- Develop dross removal techniques that reduce O&M costs.
- Demonstrate conversion of dross into useful steel-making additive.
- Optimize the refractory practice, argon flowrate, furnace temperature and process cycle times.

LABORATORY-TYPE FACILITIES

Contract #: 500-97-013 (A-7)

Contractor and Main Subcontractor: California Institute for Energy Efficiency (CIEE) and Lawrence Berkeley National Laboratory (LBNL)

Contract Amount: \$375, 000

Contractor Project Manager: Carl Blumstein
(510) 642-9590

Commission Contract Manager: Clinton Lowell Jr.
(916) 654-4554

Publication Number: P600-00-007

Project Description: The purpose of this project was to provide new technology and applications knowledge to reduce the energy intensity and improve the performance of high-tech and laboratory-type facilities. Facilities of this type frequently house cleanrooms. Examples of California industries where high-tech manufacturing and research-type facilities exist are semiconductor, electronic, biotechnology, pharmaceutical, aerospace, medical and universities.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by improving the energy efficiency of an ever-growing sector of California's industry.

Proposed Outcomes: Eight project components were identified. Each component has a goal to serve as the basis of a multi-year RD&D effort to improve energy efficiency in high tech buildings. We report on this year's objectives, outcomes, and conclusions for each project component and our progress towards reaching the goal. The eight project components and goals are:

1. Design Intent Documentation: Develop a methodology and a tool to capture design intent information and performance expectations for use throughout the building's life cycle.
2. Laboratory Fume Hood Containment: Reduce fume hood airflow requirements by at least 50 percent while improving hazard containment. An additional goal is to develop the containment technology for use in other industrial ventilation applications such as for semiconductor manufacturing.
3. Laboratory Airflow Design: Develop airflow design criteria and tools to optimize fan power consumption.
4. Field Studies/Performance Feedback: Develop a standard methodology for benchmarking complex laboratory facilities. Provide performance feedback to designers and operators.
5. Technology Transfer: Develop design guides, Web sites, workshops, and other technology transfer mechanisms.
6. Clean Room Benchmarking: Improve energy efficiency and performance of clean rooms through benchmarking across industries.
7. Clean Room Analysis Tools: Develop HVAC energy analysis and design tools for clean rooms.
8. Industry Liaison: Form collaborative alliances with industry organizations to assure success in the marketplace.

Actual Outcomes:

1. Design Intent Documentation:
 - Developed a first generation database in an MS Access to archive design intent information.
 - Captured design intent information from the UC Santa Cruz case study of the Design Guide.
2. Laboratory Fume Hood Containment:
 - Continued to develop and test a prototype low flow fume hood using a commercial hood as the base.
 - Continued to use CFD modeling to evaluate and improve performance.
 - Continued commercialization efforts including arranging for two field tests, and identification of institutional barriers to adoption of the new technology.
 - Option agreement signed with ATMI to develop and commercialize products for the microelectronics industry using the low flow containment ("air dam") technology.
3. Laboratory Airflow Design:
 - Initiated development of a computer program for modeling dynamic multi-fan airflow, including analysis of existing software tools that could reduce development time.
 - Developed an initial commercialization plan involving public goods funding, ASHRAE, and private sector software support.
4. Field Studies/Performance Feedback:
 - Continued laboratory benchmarking tool development
- including adding buildings and data to the database, and populating a second-generation database (in MS Access).
- Analyzed the data and refined the performance benchmarks, and improved the reporting scheme.
- Added listing of values for key performance parameters so they can be used in the design intent tool (see above) and compared to actual values when performance is tracked (BLISS).
- An insufficient number of laboratories were studied to transfer additional information to the electronic Design Guide (see below).
- Studied the opportunity to establish a World Wide Web interface to the database and reports, and concluded that this is the best implementation strategy.
- Determined that collection of field data to populate the database is dependent on further funding, however, strong interest was shown by EPA to use the database in a national program (Laboratories for the 21st Century) which may provide a large source of laboratory benchmark data.
5. Technology Transfer:
 - Continued support of the electronic Energy Efficient Laboratory Design Guide – maintained a Web version, distributed floppy disks, continuously evaluated Guide and made appropriate revisions.
 - Continued case study of Guide's use on a new California laboratory and initiated second case study at UC Santa Cruz.
6. Clean Room Benchmarking:
 - Continued benchmarking work, including: refinement of metrics, and expansion of case studies.
 - Arrangements have been made with PG&E to begin a major data collection effort in FY2000.
 - Disseminated case studies on LBNL's clean room Web site.
7. Clean Room Analysis Tools:
 - Continued evaluation of clean room analysis tool needs and the potential enhancements to an existing computer-based energy analysis tool (potentially DOE-2.2)
 - Determined that although a technical need exists, designers are satisfied with their existing tools and have little incentive at the present to change.
8. Clean Room Industry Liaison:
 - Hosted a clean room workshop and published the proceedings which were distributed to all attendees.
 - Hosted two clean room design charrettes, one with Genentech and one with a major San Jose electronics company.
 - Attended and participated in numerous clean room industry forums to transfer knowledge, expand network, and build industrial relationships.

TARGET 18/2.1 MATERIALS FABRICATION**Contract #:** 100-98-001 #1**Contractor and Major Subcontractors:** EPRI; Terratech Corporation

CEC Project Amount: 1999: \$180,800
 2000: \$155,800
 Total: \$336,600

Match Funding: 1999: \$1,315,354
 2000: \$561,525
 Total: \$1,876,879

Contractor Project Manager: Leo Svendsen
(973) 263-0181**Commission Project Manager:** Brian Laan
(916) 653-7963**Commission Contract Manager:** Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address the challenges the materials fabrication industry is facing from tightening profit margins, competition from abroad, and stricter environmental regulations. These challenges are pressuring materials fabricators to cut costs and improve productivity, quality, and efficiency to remain competitive. The materials fabrication industry is responsible for giving form to most of our modern conveniences; it makes the metal and rubber products, machinery, printing and publishing, furniture, and plastics. An enormous amount of energy goes into producing this range of goods, over 262 billion kWh per year. In addition, it is estimated that another 700 billion kWh of secondary load can be attributed to these sources within 100 miles of the primary plant(s).

EPRI's Materials Fabrication target offers technical applications, services, and communication and marketing tools that can help the materials fabrication industry meet these competitive challenges. Technologies like transverse flux heating, infrared curing, and powder coating can improve productivity, product quality, and environmental performance. In addition, EPRI's plant surveys and demonstrations provide information and innovative approaches to re-tailor traditional processes and cut costs in this competitive sector expertise with real customer solutions to real problems.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing technologies and methods to increase energy efficiency for materials fabrication industries; and
- Improving the environmental and public health costs/risks of California's electricity by providing technologies and

methods that reduce emissions of materials fabrication industrial sites.

Proposed Outcomes:

1. Support the use of infrared and ultraviolet powder coatings by providing technical information on these processes.
2. Support the use of electric infrared heating (IR) in industrial processes by providing market analyses and technical, economic, and performance information.
3. Conduct a Tailored Collaboration entitled "Develop and Deliver Seminar and Demonstrations of UV Powder Coatings."

Actual Outcomes:

1. Infrared and ultraviolet powder coatings.
 - Tech briefs were published on improving powder coating performance, curing polyurethane powder coatings in IR ovens, and on curing powder coatings on ATV accessories.
 - A report was published on UV curable coatings to assist California fabricators and energy service companies in better understanding UV curing.
 - A cost-comparison worksheet was developed for induction curing of coatings.
2. Electric infrared heating.
 - Tech Application Sheets were published, describing real-world applications of advanced materials fabrication technologies, including impacts on costs, energy consumption, emissions, and productivity. Applications include aluminum aging, drying and curing of silk, steel strapping, cryogenic processing of metals, and injection molding.
 - Guidelines were published to support the sales and marketing of induction heating to industrial customers.
 - Software was developed for estimating and comparing the operating costs of high-temperature heating options.
 - A technical report was published on reducing energy consumption and increasing productivity in the thermal processing of metals.
 - Twenty-three industry profiles were published, describing issues, concerns, processes, energy use, and opportunities for increasing use of advanced technologies. Industries include automotive stamping, canned fruits and vegetables, carpets and rugs, computers and office equipment, copper foundries, iron and steel foundries, meatpacking, farm machinery, hospitals, petroleum refining, and pulp and paper mills.
 - A monthly newsletter was published on developments in EPRI materials fabrication research.
3. A series of five seminar and demonstrations were held at Sacramento, San Jose, Los Angeles, Irwindale, and San Diego to present information on dry powder coatings

cured by infrared or ultraviolet light. The sessions included technical presentations and equipment demonstrations. In addition collateral materials were produced, including the *Technology Guidebook for Electric Infrared Process Heating*.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

TARGET 19/2.2 MATERIALS PRODUCTION

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Carnegie Mellon University; Edison Technology Solutions; Taratec Corporation; TU Electric

CEC Project Amount: 1999: \$134,400
2000: \$134,400
Total: \$268,800

Match Funding: 1999: \$1,070,022
2000: \$483,281
Total: \$1,553,303

Contractor Project Manager: Leo Svendsen
(973) 263-0181

Commission Project Manager: Brian Laan
(916) 653-7963

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to help the materials production industries have access to new, low-cost energy and energy efficient processes. Materials production industries (steel, aluminum, foundries, glass and cement) represent the largest sector of power demand in the industrial market. These markets, important to California's future, need to have access to low-cost energy and energy efficient processes to help lower energy-related manufacturing costs and to keep these plants in California. EPRI provides access to new or existing technologies to reduce energy use and energy bills, improve productivity, lower product cost, and improve product quality. Limited resources are available to help individual plants, particularly for evaluating new electrotechnologies. The Commission can use EPRI's resources as a source of information, data, technical expertise, and tools to help California industry thrive.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity through technologies that reduce raw material waste, reduce total energy use, increase product output per unit of energy needed, and reduce the total cost of business operations; and
- Improving the environmental and public health costs/risks

of California's electricity by applying technologies that reduce combustion processes, thereby lowering overall combustion emissions and reducing California's contribution to global climate change.

Proposed Outcomes:

1. Conduct research to support application of new and existing energy efficient technologies for California's materials production facilities.
2. Provide information and communication tools to increase the potential application of energy efficiency technologies in California's materials production facilities.

Actual Outcomes:

1. Research to support application of new and existing technologies.
 - A comparison was conducted of all-electric versus oxy-fuel glass melting to identify the benefits and concerns of conversion to electric glass melting. Findings were published in a report.
 - An investigation was undertaken to identify new market niches for a microwave technology developed to separate water-oil emulsions from the metal particulates in steel mill sludge. Findings, published in a report, will assist industries in recycling metalworking fluid and improving waste management practices.
 - A software model was developed to compare the costs of electric induction heating versus traditional gas-fired heating systems in the aluminum and steel industries.
 - A software model was developed for analyzing electronic arc furnace dust recycling.
 - An analysis was conducted and reported on the effect of melting furnace type on the cutting machinability of gray iron.
2. Communication tools.
 - A report was produced on power quality problems associated with induction furnaces.
 - Information was published on the cost and environmental advantages of electrically powered conveyor systems versus diesel-powered haul trucks for material handling in mining operations.
 - Industry segment profiles were published on the powder metal parts and products industry and the fiber-based composite materials industry. Profiles reviewed the industries' characteristics, energy usage, production statistics, and market structure.
 - Information was provided on indoor air quality (IAQ) issues for foundries to assist the CEC in better understanding the rules and regulations associated with foundry IAQ.
 - Information and guidelines were published on the costs, energy efficiency, emissions, and production advantages of nonferrous metal melting electrotechnology.

- A monthly newsletter was published covering technology developments, applications, and trends in the aluminum industry.
- A monthly newsletter was published updating developments in the steel industry.
- A monthly newsletter was published providing updates and news of EPRI projects related to materials production industries.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

TARGET 21/2.4 MUNICIPAL WATER AND WASTEWATER

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Nitrate Removal Tech; PERKINS DBA DAVID; RICE International ; American Water Works Research Foundation; Black & Veatch; BOC Group, Inc; Camp Dresser & McKee; CH2M Hill; City of Houston, Texas; Clean Earth Technologies; Edison Technology Solutions; ESG International, Inc.; Hazen & Sawyer; HDR ENGINEERING, INC.; Kennedy/Jenks Consultants; Malcolm Pirnie Inc.; McAllen Public Utilities; Nitrate Removal Technologies; ProWrite, Inc.; Tennessee Valley Authority (TVA); University of Missouri-Columbia; University of New Hampshire; Washington University; West Chester Area Municipal Authority

CEC Project Amount: 1999: \$126,000
2000: \$126,000
Total: \$252,000

Match Funding: 1998: \$1,379,214
1999: \$1,790,212
2000: \$1,195,972
Total: \$4,365,398

Contractor Project Manager: Keith Carns (314) 935-8598

Commission Project Manager: Wendell Bakken (916) 654-4042

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide technology and information on the cost effective use of energy to deliver clean drinking water, treat, dispose, and reuse wastewater, and dispose of residuals, biosolids, and brines. Advanced technologies include ozonation of drinking water, freeze/thaw waste conditioning, and ultraviolet (UV) disinfection techniques. The available supply of high quality water and sufficient wastewater treatment capacity are essential to future economic development of a region. On average, municipal water/wastewater industries comprise approximately 3

percent of the total electrical load (approximately 75 billion kWh per year). Due to population increases, the load for these industries is projected to increase by more than 20 percent over the next 15 years. Of key interest in this EPRI target is the need for clean drinking water and the use of water for industrial purposes.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing advanced technologies to cost effectively deliver clean water, and process and dispose of wastes derived from water treatment; and
- Improving the public health costs/risks of California's electricity ratepayers by providing technologies that effectively purify water and wastewater.

Proposed Outcomes:

1. Increase the potential for application of ozonation of drinking water.
2. Increase the potential for application of advanced technologies for water and wastewater treatment.
3. Increase the potential for application of Pulsed UV for Water/Wastewater Disinfection.

Actual Outcomes:

1. Ozonation.
 - A progress report was published on a feasibility study on the use of ozone disinfection system at a large-scale wastewater treatment plant.
 - A document entitled *Issues for Ozone for Drinking Water Treatment* was published.
 - A technical report was published on minimizing the operating and capital costs of ozonation systems.
 - A tech brief was published on ozone uses in small drinking water systems.
 - A report was published on Phase III of the Ozone Efficiency Project, which focused on optimization of ozone use during pre-design and design of water treatment systems.
2. Advanced technologies for water and wastewater treatment.
 - A manual was published on membrane technologies for municipal water treatment that describes different membrane technologies similarities and differences, operational parameters, and aspects to consider.
 - Tech briefs were published on results of a project conducted with California water districts to investigate ozone use, desalination, reclaimed water technologies, membrane treatment of industrial wastewater, and denitrification of potable drinking water.
 - A CD-ROM was produced with an overview of water and wastewater treatment processes.
 - A generic model was developed for an energy and water quality management system.

- A microporous membrane pretreatment and reverse osmosis desalination system was tested in a California wastewater reclamation project, and results were reported.
 - A report was published on VARIO-ROTM, a promising pumping and energy recovery technology for the reverse osmosis desalination process.
 - A tech brief was published on technologies for improving water desalination.
 - A document was published on desalination of brackish water and seawater.
 - A tech brief was published on water treatment plant residuals.
 - A report was published on the status of small-system, onsite decentralized wastewater treatment plants in the United States.
 - A workshop was conducted entitled "Promising Electrotechnologies to Enhance Water and Wastewater Treatment."
3. Pulsed Ultraviolet Light for drinking water disinfection.
- A report was published on pulsed UV light for drinking water disinfection and membrane fouling control.
 - A tech brief was published on the results of research conducted by the Metropolitan Water District of Southern California to evaluate the effectiveness of pulsed UV light for drinking water treatment.
 - A progress report was published on pilot testing of four different UV reactor configurations and three types of lamps for potable water disinfection.
 - A report was published on a UV demonstration at a wastewater treatment plant in Poughkeepsie, New York.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

TARGET 22/2.5 FOOD PROCESSING

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Apogenics, Inc.; C&S AgriSystems; Cornell University; Edison Industrial Systems Center; Iowa State University; New York State Energy Research & Development; Plumrose USA Inc; ProWrite Inc; Sandridge Food Corporation; University of California, Davis; University of Minnesota; Washington State University; WaterTech Partners; Graham Dee; Imbroglia Cures Inc.

CEC Project Amount: 1999: \$96,000
2000: \$96,000
Total: \$192,000

Match Funding: 1999: \$426,810
2000: \$376,661
Total: \$803,471

Contractor Project Manager: Myron Jones

(650) 855-2993

Commission Project Manager: Ricardo Amon
(916) 654-4019

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide California's food processing industry with new electrotechnologies that increase energy efficiency and reduce environmental impacts that can help keep this sector of the California economy productive and energy efficient. Concerns about the worldwide environment and demand for food are just a few of the many challenges this important sector of California industry must meet to stay competitive. A competitive food processing industry is more likely to stay in California and ensure that California's rapidly growing population has a safe and adequate food supply. EPRI offers the latest tools and information such as technical services, communication tools, and innovative initiatives that focus on food safety—a top priority among consumers and regulators today. Electrotechnologies like ozonation and pulsed power for sanitation are some of EPRI's state-of-the-art solutions to the industry's most pressing concerns.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and implementing technologies that improve productivity and energy efficiency for food processing industries; and
- Improving the environmental and public health costs/risks of California's electricity by reducing fresh water supply needs, plant wastewater discharge, and improved food sterilization.

Proposed Outcomes:

1. Support research and provide information to improve the competitiveness of the California food processing industry through implementation of technologies that increase energy efficiency, reduce environmental impacts, and provide safer, more productive processes.

Actual Outcomes:

1. Research and information to improve the competitiveness of the food processing industry.
 - Results were published of a study of membrane treatment to reduce water use and ozonation for sanitation at a poultry processing plant.
 - A resource guide was published for evaluation of food irradiation options.
 - Technical and market information were compiled on the use of ozone for improved sanitation and water treatment in food processing.

- Three reports were published on membrane treatment, pulsed power technologies, and other process water treatment options.
- Research results were reported of a study of the use of electron beam irradiation and high-pressure technologies to reduce the effects of microorganisms on poultry products.
- The food industry scooping study report was revised and updated as *Food Industry 2000*. The report provides an overview of the food industry.
- Findings were released from a study that tested the use of ozone as a replacement for chlorination in wheat steeping water used in wheat processing.
- A monthly newsletter was published on developments and trends in the food processing industry.
- EPRI's Membrane Trailer Demonstration Unit made on-site visits to a food processor to demonstrate and test advanced membrane technologies.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

TARGET 26/2.5 AGRICULTURE

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Edison Technology Solutions; Electrochemical Design Associates; G & L AgriTec; Hawaiian Electric Company Inc; North Carolina State University; ProWrite Inc; Purdue University; SoilZone, Inc.; Texas State Technical College; University of Georgia Research Foundation Inc; Jonne Berning; SoilZone Inc.

CEC Project Amount: 1999: \$97,000
2000: \$72,000
Total: \$169,000

Match Funding: 1999: \$292,716
2000: \$400,661
Total: \$693,377

Contractor Project Manager: Myron Jones
(650) 855-2993

Commission Project Manager: Ricardo Amon
(916) 654-4019

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to offer a complete package of advanced energy solutions and technical support to increase farm production and reduce costs. U.S. farms spend about \$12 billion each year for energy. Approximately \$3.8 billion of that goes toward electricity purchases. Efficient use of electricity has a critical impact on profitability. Today's farmers and agribusinesses rely heavily on advanced technologies and science to turn a profit. Where once farmers turned a watchful eye to the

sky for signs of rain, satellites now give them detailed snapshots of weather conditions around the country. Farmhands have been replaced by energy-efficient motors and other electrotechnologies to the tune of 44 billion kWh of electricity consumption annually. This EPRI target also provides marketing communications tools to provide access to these energy solutions to agribusinesses.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing energy solutions for agribusinesses to increase farm production and reduce costs; and
- Improving the environmental and public health costs/risks of California's electricity by demonstrating the use of ozone as a replacement for chemicals such as methyl bromide for purification, fumigation, and disinfection.

Proposed Outcomes:

1. Support the potential for use of ozone in place of chemicals or other methods in agriculture.
2. Provide experience and knowledge on innovative technologies and practices to increase production and reduce costs in agribusiness.
3. Support the use of energy-efficient technologies and practices in agriculture.
4. Conduct a Tailored Collaboration entitled "Predicting Agricultural Growth After Ozone Treatment" to test the technical efficacy of treating agricultural soils with on-site generated ozone gas to reduce pest pressures on plant growth.

Actual Outcomes:

1. Use of ozone.
 - A report was published entitled *Ozone in the Food and Agriculture Industries*.
 - A petition was made to the Federal Drug Administration to gain regulatory acceptance of ozone treatment of food products in agriculture and food processing. The petition is under review by the FDA and a ruling is expected in 2001.
 - An ozone conference was held in September 1999 in Tulare, and abstracts were published.
2. Technologies and practices to increase production and reduce cost.
 - A report was published on freshwater recirculation aquaculture systems that hold the potential to make fishfarming more profitable.
 - A report was published on a North Carolina demonstration of an aquaculture facility utilizing water re-use technology.
 - Results of a study were published on poultry spiking mortality, highlighting the importance of purified drinking water in poultry production.
 - Results of study were published on stray voltage and animal sensitivity levels.

- A report was published on the potential for drip irrigation of technical row crops.
 - Information was published on a greenhouse study of very intense lettuce production.
 - A report was published on closed-cycle shrimp farming.
3. Energy efficient technologies and practices.
- A report was published on the McLeod harvest method, an innovative grain harvesting technology that offers a promising alternative to combine harvesting, especially for small farms.
 - Technical and energy consumption information were published on the application of variable-speed drives to increase the energy efficiency and controllability of agricultural fans.
 - Findings were published on the use of static phase adaptors to utilize 110-volt current on large three-phase irrigation motors.
4. Field trials were conducted for several crops, including carrots and tomatoes, and initial success was reported. Results were summarized in a report entitled Ozone Gas as a Soil Fumigant.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

TARGET 27 ELECTRONICS INDUSTRY

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; J&M Associates; Alzeta; International Sematech; J&M Associates; Sematech, Inc

CEC Project Amount: 1999: \$80,000

Match Funding: 1999: \$551,868

Contractor Project Manager: William M. Smith
(650) 855-2415

Commission Project Manager: Clint Lowell
(916) 654-4554

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address the major energy, productivity and environmental issues of the expanding California electronics industry. Industries in this rapidly growing market sector—including manufacturers of semiconductors, printed wiring boards, telecommunications equipment, computers, and peripherals (all major California industries)—face these issues as they strive to sustain or expand their position in the global marketplace. Yield, equipment utilization, energy efficiency, power quality, and water management are essential issues that all California electronics manufacturers must address. In addition, many firms in this internationally competitive industry strive to keep their product development efforts highly confidential.

EPRI's Electronics Industry Target follows a twofold strategy in working with these proprietary-minded industry sectors. The initial step in engaging any electronics industry sector involves the creation of an "industry gateway" through the formation of strategic alliances and project partnerships with industry organizations, through which project proposals may be credibly prioritized. The second step entails developing leveraged projects that create products of mutual interest to the industry sector(s) involved and the target funders. Such leverage may come in the form of supplemental funding from target funders or access to industry funded project results that only target funders can obtain. This strategy increases the likelihood that the project results will be used by the industry sector(s) that can benefit from those results, as the industry gateway approach permits a continuing connection to industry, even after a specific project has been completed.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by promoting energy efficient manufacturing tools and processes, including manufacturing facility operations. The target also promotes electrotechnology applications (e.g., for water management) that result in the minimum use of electricity per unit of product, while maximizing the value of electricity by reducing overall production costs; and
- Improving the environmental and public health costs/risks of California's electricity by engaging in research to improve air, water, and solids emissions through pollution prevention, in-plant recycling, and end-of-pipe mechanisms in electronics plants.

Proposed Outcomes:

1. Provide information to accelerate the development and market penetration of energy- and water-efficient technologies to make productivity and environmental gains in California electronics manufacturing.
2. Compile and disseminate up-to-date information on electronics industry market conditions, primary issues, available technologies for addressing these issues, and industry research progress and needs.

Actual Outcomes:

1. Energy- and water-efficient technologies for electronics manufacturing.
 - A report was published describing an evaluation of a perfluorocompound (PFC) capture and recovery unit designed to extract PFCs from the combined exhaust of 20 or more tool process chambers.
 - A report was published on good tool exhaust optimization practices that will help California companies reduce clean-room energy use and

makeup air costs associated with inefficient static pressure losses and exhaust from process tools.

- Access was given to six 1998 reports. These reports included: *Summary of Wafer Rinse Optimization Studies at Advanced Micro Devices (AMD), Motorola, and Texas Instruments (TI) Fabs, International 300 mm Initiative (I300I) Tool Utility Usage Study, Evaluation of an SG Water Systems GmbH Prototype Electrodeionization (EDI) Unit, Addendum to the Sandia Evaluation of an SG Water Electrodeionization (EDI) Unit Report, Evaluation of Commercially Available*

On-Line Total Oxidizable Carbon (TOC) Analyzers for Monitoring Recycled Water, and Wafer Rinse Optimization Studies at Digital-Intel, SEMATECH, and Texas Instruments Fabs: Summary Report.

2. A report entitled the *Worldwide Fab Energy Survey Report* was published.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

Renewable Energy Technologies

PHOTOVOLTAIC (PV) CHARGEPORT DEMONSTRATION

Contract #: 500-97-011

Contractor: San Diego Gas & Electric Company (SDG&E)

Contract Amount: \$90,000

Contractor Project Manager: Sally Wirsching
(619) 654-8269

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Publication Number: P600-00-034

Project Description: The purpose of this project was to demonstrate the integration of electricity-generating photovoltaic (PV) panels into a covered parking port to charge electric vehicles. This application of PV will illustrate how the panels can be integrated into the current electrical system for practical applications.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing a clean source of electricity for zero-emission vehicles.

Proposed Outcomes:

- Establish guidelines for future deployment of PV's for electric vehicle charge stations without the need for extensive engineering.

Actual Outcomes:

- This project demonstrated that photovoltaics can be integrated with electric vehicle chargeports to partially offset the amount of electricity used to charge electric vehicles.

PHOTOVOLTAICS

Contract #: 500-97-012-11

Contractor and Major Subcontractors: Edison Technology Solutions and Utility PhotoVoltaic Group (UPVG); U.S. Department of Energy (USDOE); Emerging Renewables

Contract Amount: \$1,000,000

Match Funding: \$1,427,000

Contractor Project Manager: Steve E. Taylor
(626) 815-0530

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Publication Number: P600-00-018

Project Description: The purpose of this project was to operate and monitor twelve photovoltaic (PV) systems to evaluate their year-round system performance and efficiency. This evaluation was to document that photovoltaics are applicable on a wide scale to the typical building types located in the dense urban areas of Southern California.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by documenting the application of a clean electrical generation technology; and
- Improving the reliability/quality of California's electricity because PV offers an attractive, environmentally benign renewable energy alternative for distributed electrical generation.

Proposed Outcomes:

- Support Edison Technology Service's (ETS) Solar

Neighborhood Program by helping to commercialize photovoltaic technology, educate and increase public awareness, and deploy photovoltaics into high-value, high-visibility applications by evaluating system performance and efficiency as compared to expected results, and evaluating the seasonal effects of year-round PV operations in California.

Actual Outcomes:

- Properly designed and situated PV systems were shown to operate within 15 percent of their expected system efficiency specifications.
- The seasonal effects of the various PV systems showed that with increasing panel temperatures, efficiencies decreased. Conversely, when the panels were cooler at the same irradiance level, system efficiency increased. Increasing daylight hours in the summer increased overall energy production. The decreased panel efficiency occasioned by increased summer temperatures was more than offset by longer daylight hours. Peak power reduction was offset by increased energy production.

SOLAR TWO

Contract #: 500-97-012-10

Contractor: Southern California Edison

Major Subcontractors: Bechtel International and Boeing Corporation; Rocketdyne Division

Contract Amount: \$1,200,000

Match Funding: \$52,880,000

Match Funding participants:

Bechtel International: \$3,095,000

Boeing Company, Rocketdyne Division, and Other Industry: \$1,888,000

Electric Power Research Institute: \$1,750,000

Southern California Edison: \$10,516,000

Los Angeles Department of Water and Power: \$1,261,000

South Coast Air Quality Management District: \$100,000

PacificCorp: \$1,261,000

Arizona Public Service and Salt River Project: \$1,261,000

Idaho Power: \$1,261,000

Nevada Power: \$100,000

Chilean Nitrate Corporation: \$1,000,000

U.S. Department of Energy: \$24,250,000

Other Contributors: \$2,615,000

Contractor Project Manager: Bill Stoke (909) 394-8986

Commission Contract Manager: Alec Jenkins (916) 654-4597

Publication Number: P600-00-017

Project Description: This project completes the testing and evaluation of the 10 MW Solar Two Central Receiver

Project. Solar Two uses concentrated solar energy to produce steam for electric generation. It is a proof-of-concept power plant that demonstrates the practical combination of the solar central receiver concept and the use of molten salt as an efficient, nontoxic heat transfer and energy storage fluid. The central receiver/molten salt design is presently the only practical technology for collecting and storing solar thermal energy for electric generation on demand, whether that demand is hours or days after the energy has been collected.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by using a sustainable energy resource to diversify the State's electricity supply system;
- Improving the energy cost/value of California's electricity by overcoming the intermittent nature of traditional solar electric generation so that even baseload power can be provided;
- Improving the environmental and public health costs/risks of California's electricity by using a zero emission generation technology with a nontoxic energy storage medium (molten salt); and
- Improving the safety of California's electricity by using a nonflammable energy transfer fluid (molten salt).

Proposed Outcomes:

- Test and validate the technical characteristics including performance of the nitrate salt receiver, energy storage system, and steam generator subsystems; and generation dispatch capability.
- Improve the accuracy of economic projections for commercial projects by increasing the database for capital, operating, and maintenance costs.
- Document overall project results for use by public and private R&D programs and the solar industry to foster wider interest in commercial plants.

Actual Outcomes:

- Completed all primary tests and data collection goals, including demonstrating full operational flexibility and successful operation of an advanced receiver panel technology.

Specific technical outcomes:

- Gross turbine output as a function of heat input to the steam generator agreed well with design estimates.
- The efficiency of the molten salt receiver agreed well with design predictions.
- The energy storage subsystem fully met efficiency predictions.
- Between July 1 and July 7, 1998, the plant demonstrated a key advantage of the molten salt central receiver by

delivering 24 hour a day continuous solar-electric power to the grid (153 hours). The project has therefore demonstrated full dispatch capability.

- Improved the accuracy of economic projections by obtaining actual performance data for use in scaling the design performance prediction model, Solergy.
- Improved plant cost predictions by documenting refinements in operation and maintenance procedures and expected outcomes in cost and performance, as well as design and operational refinements to be incorporated in the subsystems for commercial plant
- SunLab (the solar thermal program collaboration between the National Renewable Energy Laboratory) is documenting the overall project results for use by public and private R&D programs and the solar industry to foster wider interest in commercial plants.

SECONDARY DISTRIBUTION SYSTEM IMPACTS OF RESIDENTIAL EV CHARGING

Sole-source Agreement #: 500-98-059

Agency Partners: Georgia Technology Research Corporation

Commission Funding: \$100,000

Match Funding: \$95,000

Project Manager: Frank Lambert (404) 675-1855

Commission Project Manager: Mark Rawson (916) 654-4671

Project Description: The purpose of this contract is to cost share a collaborative project to analyze the power quality impacts of large single-phase residential loads, such as electric vehicle chargers, computer equipment, appliances, and HVAC to residential secondary distribution (customer-side) systems.

The market penetration of these large single-phase residential loads is a concern to distribution utilities, electric power providers and consumers alike. To the power providers, it is a potential power quality, power delivery, and energy consumption concern. For the distribution utilities and consumers, it is a concern in terms of distribution system reliability, house or site electrical system reliability, and energy costs. Impacts of consumer appliances on the utility secondary distribution system are network externalities. Electricity providers have no regulatory responsibility for network externalities. However, electricity providers do recognize the importance of this issue and are cost sharing this project. The collaborative includes Southern California Edison, Pacific Gas and Electric, Sacramento Municipal Utility District, Virginia Power, Southern Company, and Florida Light and Power.

This project supports the PIER Program objective of:

- Improving the reliability/quality and efficiency of California's electrical transmission, distribution and delivery grid by addressing power quality, power delivery, and energy consumption concerns.

Project Status: The project has been completed. The main conclusions of the project based upon utility systems and chargers investigated were:

- Commercial light-duty on-road EV chargers engineered to National Electric Vehicle Infrastructure Working Council (IWC) guidelines based upon IEC 1000-3-4 do not give rise to excessive voltage total harmonic distortion (THD) on the secondary side of the transformer. Two critical elements that make these guidelines effective are a minimum total power factor of 95 percent and a maximum current THD of equal to or less than 20 percent.
- The main cause of concern is the overloading of the distribution transformer with widespread use of EV chargers, assuming the chargers meet voluntary IWC guidelines such that voltage THD is not an issue. Still, utility service planning groups should ask for kVa and true power factor values in addition to the kW values for any rectifier or other non-linear load.

Interim results of this project have been presented and published at the North American Electric Vehicle Infrastructure conference in November 1999. A final report was presented at the Electric Vehicle Symposium in October 2000. Project results have also been provided to the IEEE Task Force on Single Phase Harmonics and a summary provided to EPRI for release to the IWC.

TARGET 66/53 RENEWABLE TECHNOLOGY OPTIONS AND GREEN POWER

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; D. Iem Dba Augenstein; Edward A. Holt; Karen Conover; Dr. J. M. Morabito; Thomas Morton; Ron Nierenberg; Rla Consulting; Patricia Weis Taylor; Wind Economics & Tec; Ascension Technology; Cedar Falls Utilities; Central & South West Services, Inc.; City of Brownfield; Cummins Power Generation, Inc; Fortum Power and Heat; Foster Wheeler Development Corp; Green Mountain Power Company; Kansas Electric Utilities Research Program; Nebraska Public Power District; Nevada Power; New York State Electric and Gas; Pennsylvania State University; Princeton University; Resolve, Inc.; Risoe National Laboratory; Southern Research Institute; Tennessee Valley Authority; University of Delaware; University of Illinois at Urbana; University of South Florida; University of Texas at Austin; York Research Corporation

CEC Project Amount: 1999: \$348,480
2000: \$330,000
Total: \$ 678,480

Match Funding: 1999: \$1,790,212
2000: \$1,904,644
Total: \$3,694,856

Contractor Project Manager: Dan Rastler (650) 855-2521

Commission Project Manager: George Simons

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to address the barriers renewable energy technologies face in spite of customer enthusiasm, technology advances, and dropping prices. Still needed are standardized technology and control protocols, more efficient operating strategies, and broader definitions of the true benefits of renewable energy. This EPRI target packages objective information and real-world experience focusing on three main options—wind power, photovoltaics, and biomass. Specifically, EPRI will manage California's wind energy forecasting project, and broker other collaborative projects with utilities, DOE and others. EPRI will deliver results in areas including biomass cofiring with natural gas, wind power, a renewable energy technical assessment guide, and PV interconnections. This EPRI target provides information on renewable technology performance and costs, analyzes the energy and non-energy benefits of deploying renewable technologies, and offers an inside look at the working experiences of companies around the world.

This project supports the PIER Program objectives of:

- Improving the energy cost value of California's electricity by increasing the potential for application of renewables by providing accurate information on performance, energy and non-energy benefits, costs, and best practices;
- Improving the reliability/quality of California's electricity by facilitating the integration of electricity from distributed generation technologies into the State's electricity transmission and distribution system.

Proposed Outcomes:

1. Provide accurate information on wind power technology, markets, and issues to increase the potential for its application in California.
2. Develop a wind forecasting capability to reduce the financial risk for wind generators to bid to supply real-time and next-day wind energy and ancillary benefits to the California Independent System Operator (ISO), Power Exchange (PX), and Automated Power Exchange (APX).
3. Provide accurate information on photovoltaics technology, markets, and issues to increase the potential for its application in California.
4. Provide accurate information on biomass technology, markets, and issues to increase the potential for its application in California.
5. Conduct a Tailored Collaboration entitled "Biomass Cofiring with Natural Gas in California: Phase I Study" to identify feasible options for integrating biomass use with natural gas power systems.

Actual Outcomes:

1. Wind power information.
 - Performance test results were compiled from the DOE-EPRI Wind Turbine Verification Program, which features seven projects conducted throughout the world, documenting data on operations and availability of five different leading technologies. Findings were published in news bulletins and eight technical reports.
 - A report entitled *Wind Power Productivity Improvement and Procurement Guidelines* was published.
 - Improvements were suggested to the wind technology of Zond, the only large U.S. manufacturer of wind power technology, which is located in California.
 - The *EPRI Renewable Energy Technology Assessment Guide (TAG-RE)* was published with a section on wind power. The TAG-RE provides comprehensive, detailed information on the technology status, development issues, performance, cost, installed capacity, and markets for renewable technologies.
 - Information was compiled on wind power as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
2. Wind power forecasting.
 - Development of a modeling system to issue twice-daily forecasts of hourly wind generation was initiated in parallel by three different companies. Development and testing are to continue in 2001.
 - A report was published on the European Union wind energy forecasting model development and testing.
3. Photovoltaics (PV).
 - The *EPRI Renewable Energy Technology Assessment Guide (TAG-RE)* was published with a section on solar PV.
 - Information was compiled on solar PV as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
 - Guidelines were provided for identifying, planning, and implementing high-value PV systems, as well for interconnection with the grid.
 - EPRI representatives attended meetings of the Utility Photovoltaic Group to assist in planning and execution of the national PV Rooftop Initiative.
4. Biomass.
 - The *EPRI Renewable Energy Technology Assessment Guide (TAG-RE)* was published with a section on biomass.

- Information was compiled on biomass as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
 - The Biomass Cofiring Applications Guide was produced.
 - EPRI monitored and reported on R&D and commercial products and programs that offer improvements in knowledge or performance of biomass crop and energy systems.
5. Tailored collaboration on biomass cofiring.

- A report was published presenting the major cost and performance parameters of systems that enable natural gas to be augmented by 10% biomass fuel. The report provides estimates of the extra cost for the electricity to be generated from biomass.
- Field test results were published from the Bailly and Seward demonstrations.

Project Status: The Commission's participation in this target ended as of December 31, 2000.

Environmentally-Preferred Advanced Generation

DISTRIBUTED RESOURCES DEMONSTRATION

Contract #: 500-97-011-04

Contractor: San Diego Gas & Electric Company (SDG&E)

Contract Amount: \$450,000

Contractor Project Manager: Al Figueroa (619) 654-8614

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Project Description: The goal of this project is to demonstrate how small distributed generation systems can be seamlessly integrated into existing electric distribution systems. Distributed generation will allow additional electric generation facilities to be installed without undertaking construction of large commercial power plants and will provide backup for the current electrical distribution system.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by improving the integrity, reliability and safety of California's energy supply system through diverse distributed electrical resources. In addition, this project addresses electrical distribution issues raised by deregulation of the California electricity industry.

Proposed Outcomes:

- Studies for defining standards for the interconnection of distributed energy resources.
- Remote dispatching and control strategies for distributed energy resources will be examined.

Actual Outcomes: The equipment for this project is currently being installed and tested.

FUEL CELL DEVELOPMENT AND DEMONSTRATION

Contract #: 500-97-011-02

Contractor and Major Subcontractors: San Diego Gas and Electric (SDG&E)

Contract Amount: \$300,000

Contractor Contract Manager: Al Figueroa
(619) 654-8614

Commission Contract Manager: Dr. Avtar Bining
(916) 657-2002

Publication Number: P600-00-033

Project Description: The purpose of this project is to demonstrate the performance and reliability of a molten carbonate fuel cell (MCFC) electric generating technology with upgraded system components. Proving the efficiency and effectiveness of fuel cells will help propel this low-emission, electric generation technology into the marketplace. This project will assist in the advancement of MCFC technology by providing labor and selected materials for modifying the existing balance-of-plant (BOP) components designed for a 250 kW capacity MCFC demonstration plant at the Marine Corps Air Station Miramar. Balance-of-plant modifications are required to accept the next generation fuel cell stack having a capacity of 75 kW. An improved design of MCFC fuel cell stacks will be tested and demonstrated at the Miramar plant. Other system components, including a new hot gas blower and turbo charger, will also be tested. Additionally, an assessment of the technical feasibility of integrating micro-turbine generator technology with the MCFC technology will be done.

This project supports the PIER Program objective of improving of:

- Improving the reliability/quality of California's electricity by offering energy efficient, low-emission alternate sources of electricity that diversify the State's electrical generation resources.

Proposed Outcomes:

- A modified BOP suitable to accept M-C Power's 75 kW MCFC stack.
- Testing and evaluation of a new hot gas blower and turbocharger for a reliable performance.
- Assessment of technical feasibility of integrating micro-turbine technology with the MCFC technology.

Actual Outcomes:

- The project resulted in a modified reliable BOP suitable for accepting the M-C Power's 75 kW MCFC stack.
- New hot gas blower and turbocharger units were tested and evaluated. The new units have been found very reliable during the BOP testing and subsequent 75 kW MCFC stack testing. The system has been continuously operating for nearly 3000 hours.
- Assessment has revealed very favorable prospects of integrating the micro-turbine technology with the MCFC technology.

SOLID-OXIDE FUEL CELL/MICRO TURBINE GENERATION HYBRID

Contract #: 500-97-012-07

Contractor and Major Subcontractors: Southern California Edison and Siemens-Westinghouse / Ingersoll Rand Energy Systems (IRES) (formerly Northern Research Engineering Corporation (NERC)); University of California, Irvine (UCI); Energy Systems Services Corporation; Paragon

Contract Amount: \$2,000,000

Match Funding: \$14,900,000

Contractor Project Manager: John Leeper
(626) 302-8936

Commission Contract Manager: Arthur J. Soinski
(916) 654-4674

Project Description: The purpose of this project was to perform a proof-of-concept demonstration of the ability to operate two dissimilar distributed generation technologies as an integrated system. The 250 kW integrated hybrid system consists of a 220 kW pressurized solid oxide fuel cell (PSOFC) and 30 kW microturbine generator (MTG). Atmospheric emissions from fuel cells are very low because fuel cells convert fuel to electricity by an electrochemical process without combustion. MTGs

typically have higher atmospheric emissions than a fuel cell. However, in the hybrid, the hot exhaust gases exiting the PSOFC is expanded through the MTG turbine, driving the compressor to pressurize the fuel cell. Remaining available energy is used to drive an electric generator to produce additional electric power. The increased power generation occurs with no increase in either fuel consumption or atmospheric emissions. The project risk is high for three reasons. First, the Siemens Westinghouse SOFC has not been operated in pressurized mode previously. Second, SOFC technologies are still in the development stage. Third, integration of a fuel cell a MTG has not been attempted before.

Engineering design studies predict that mature, commercial hybrid units will be more cost competitive than stand-alone fuel cells. Successful completion and utilization of this technology will result in air quality benefits through a reduction in NO_x and greenhouse gas emissions. The integrated PSOFC and MTG hybrid will result in a 60 percent electrical efficiency-generating device that is equal to or greater than any other form of fossil-energy generation.

This project supports the PIER Program objective of:

- Improving the energy cost/value and improving environmental and public health costs/risk of California's electricity by providing reliable, diverse, energy-efficient, low-emission distributed electrical resources.

Project Outcomes:

- The PSOFC Factory Acceptance Test was successfully completed with 110 hours of operation at the factory.
- Installation of the hybrid at the University of California, Irvine was completed in May 2000. System startup occurred in June 2000. Proof of concept was achieved: sustained operation with the PSOFC supplying thermal energy to drive the MTG was demonstrated.
- The Site Acceptance Test (SAT) after 100 hours of operation, the principal part of the demonstration funded by PIER, was successfully completed on January 13, 2001.
- The hybrid system operated with minor exceptions from the original design criteria.
- After 153 hours of operation, overheating and failure of the PSOFC negative power lead occurred. Operation was suspended, and the PSOFC was returned to the manufacturer for repair.

Project Status:

The proof of concept demonstration was successful. The Final Report will be submitted prior to the contract termination date of June 30, 2001. The Contractor will

provide the report on the full test program, extending over 3,000 hours, as a courtesy.

MICRO-TURBINE GENERATOR (DISTRIBUTED GENERATION)

Contract #: 500-97-012-08

Contractor and Major Subcontractors: Edison Technology Solutions and University of California, Irvine (UCI); Energy System Services Corp.; CAMS; Paragon; Capstone Turbine Corporation; Bowman Turbines, Inc.

Contract Amount: \$500,000

Match Funding: \$1,500,000

Contractor Project Manager: Stephanie Hamilton (626) 815-0514

Commission Contract Manager: Dr. Avtar Bining (916) 657-2002

Publication Number: P600-00-016

Project Description: The purpose of this project is to test small gas turbines in distributed electrical generation applications. This project is part of a public/private sector \$2 million collaborative microturbine generator (MTG) transition procurement and testing project at the University of California, Irvine (UCI). The project partners include UCI, U.S. DOE, EPRI, and several MTG manufacturers.

This project will procure and test, for the first time, small gas turbine technology in distributed generation applications. The MTG collaborative program consists of extrapolating the automotive MTG design into a long-life machine suitable for use as a land-based electric generation technology. The PIER program's transition project funding will fund the procurement and testing of two Bowman microturbine generators, a major element of this program. The MTG, which is typically rated in the 30-60 kW range, is a small combustion turbine that has an integral high-speed generator.

This project supports the PIER Program objectives of:

- Improving the reliability/quality and the energy cost/value of California's electricity by offering alternatives for distributed generation applications that will reduce the costs of transmitting and distributing electricity;
- Improving environmental and public health costs/risk of California's electricity by reducing NO_x emissions from on-site electrical generation; and
- Impacting local and state economy by contributing information to help in developing an emerging distributed generation technology industry in California.

Proposed Outcomes:

- Enhance system reliability - MTGs can enhance system

reliability benefits for California utility ratepayers by reducing T&D operating costs.

- Reduced NO_x emissions.
- Economic Development –Procure MTGs from two California-based MTG manufacturers. If successful, this project will contribute information to help in developing an emerging distributed generation technology industry in California.

Actual Outcomes:

- Two Bowman (35 kW and 60 kW) and a Capstone 28 kW were tested. The Bowman 35 kW operated for 100.6 hours, the Bowman 60 kW operated for 4.2 hours and the Capstone 28 kW operated for 1,879 hours. Both Bowman units operated on a sporadic basis due to component failures and operational restrictions imposed by unacceptably high noise levels. The Capstone microturbine operated within the manufacturer's claimed efficiency rating at full load.
- The Bowman 35 kW emissions test data could not be obtained due to unacceptable technical conditions. However, both the Bowman 60 kW and the Capstone 28 kW units emissions test showed NO_x and CO levels that met or were well below limits set by the SCAQMD.
- The Capstone 28 kW unit's power quality measurements met the Institute of Electronics Engineering's standard for harmonic control in electric power systems. The Bowman units provided for testing require additional enhancements in order to improve operability and reliability. Further testing of MTGs is required to test the validity of the manufacturers claims and to determine if they can become a vital part of the State's electrical generating capacity mix.

A NOVEL STEAM REFORMING REACTOR FOR FUEL CELL DISTRIBUTED POWER GENERATION

Contract #: 500-97-038

Contractor and Major Subcontractor: GE Energy and Environmental Research (EER) and Phillips Petroleum Company

Contract Amount: \$349,852

Match Funding: \$303,457

Contractor Project Manager: Jerald Cole (949) 859-8851

Commission Contract Manager: Arthur J. Soinski, Ph.D. (916) 654-4674

Publication Number: P600-00-041

Project Description: The purpose of this project was to further develop a novel steam reforming process to convert natural gas to a hydrogen-containing mixture on a small scale. There are two novel aspects of the patented technology. First, the reformer and its catalyst are heated internal, thereby eliminating the need for an external

furnace. Second, a carbon dioxide absorber is mixed with the reforming catalyst. This improves product gas quality, improves thermodynamic efficiency, and reduces the cost of the reformer. The intended market for the reformer is as the hydrogen source for a residential proton exchange membrane fuel cell (PEMFC).

This project supports the PIER Program objective of:

- Improving the reliability/quality, improving the environmental and public health costs/risks and improving the energy cost/value of California's electricity by advancing the use of low-emission, low-cost, distributed resource fuel cell technologies.

Technical Objectives:

Technical and economic performance goals included:

- extending the catalyst and absorber life (greater than 5,000 hour);
- hydrogen production volume exceeding 25,000 cubic feet per day;
- 75-85 percent conversion efficiency of fuel to hydrogen;
- low atmospheric emissions (especially important because the fuel cell stack itself has negligible emissions); and
- cost targets that would make PEMFCs competitive with centralized power generation.

Project Outcomes:

- A catalyst with a projected lifetime greater than 4,350 hours was developed.
- The catalyst exceeded the 50 percent utilization goal by 22 percent.
- Only one carbon dioxide absorber, commercial dolomite, was identified as being suitable.
- Some of the technical objectives were not achieved because the pilot reformer had insufficient steam production (steam is needed in the reforming reaction) and inadequate reactant preheating.
- Engineering analyses suggest that the project objectives can be achieved with further development efforts.

Project Status: The project and the Final Report have been completed.

75-KW MOLTEN-CARBONATE FUEL CELL (MCFC) STACK VERIFICATION TEST

Contract #: 500-97-039

Contractor and Major Subcontractors: M-C Power Corporation and San Diego Gas and Electric; Bechtel National, Inc.; Alternative Energy Systems Consultants; and Stewart and Stevensen

Contract Amount: \$1,000,000

Match Funding: \$1,956,841

Contractor Project Manager: Thomas Benjamin
(630) 986-8040, Ext. 159

Commission Contract Manager: Dr. Avtar Bining
(916) 657-2002

Publication Number: P600-00-038

Project Description: The purpose of this project is to demonstrate the energy-producing performance of advanced design molten carbonate fuel cell (MCFC) stack components in a 75 kW electric power generator. The 75 kW MCFC Stack Verification Test Project is an important step toward commercializing MCFC power generation technology in the year 2002. The test will be conducted at the existing test facility at Marine Corps Air Station Miramar in San Diego. Based on information from a prior Miramar test and small-scale factory tests, advances in fuel cell components and stack design have been identified. A new 75 kW stack will be built incorporating the advanced technology and will be installed at Miramar for testing. The test program participants include the U.S. Department of Energy, the California Energy Commission, San Diego Gas & Electric, and M-C Power, Incorporated.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by developing an efficient electric generating technology that emits negligible levels of ozone and smog precursor pollutants and reduced levels of carbon dioxide; and
- Improving the reliability/quality of California's electricity by demonstrating fuel cell technology for distributed generation applications.

Proposed Outcomes:

- Verify the long term current density performance of M-C Power's most advanced stack design in full size cells under field conditions.
- Evaluate the effect of anode recycle on generator performance.
- Gather operating data upon which to base the design of future commercial prototype generators.
- 50-80 percent higher efficiency than conventional combustion-type generators.
- Negligible emissions of ozone and smog precursor pollutants.
- Reduced production of carbon dioxide exceeding target of climate change initiatives.
- Higher reliability of service – high-quality power, few moving parts and no transmission lines; reduced consumption of fuel resources; and competitive cost of electricity.

Actual Outcomes:

- M-C Power, Inc. successfully completed nearly 5 months of testing of its integrated, pressurized molten carbonate fuel cell (MCFC) power plant technology.

- Testing took place at M-C Power's system verification test facility at the Marine Corps Air Station (MCAS) Miramar in San Diego, California. Performance operations of a new improved design 75 kW stack, associated systems and components were initiated on July 4, 1999 and continued until the end of November 1999.
- The MCFC power plant operated for about 3,300 hours and generated 250 MWh of electricity. The power system generation consistently exceeded the 75 kW rating throughout the test period.
- Nitrogen oxide emission levels were below 0.4 ppm, which verified significant environmental benefits of MCFC technology.
- System performance exceeded expectations and provided valuable design and operating information which is essential for the design of a commercial unit. The commercial unit will be ready for testing in 2001.

ANALYSES AND TECHNOLOGY TRANSFER FOR FUEL CELLS

Contract #: 500-98-052

Agency Partners: University of California, Irvine (UCI); Southern California Edison; M-C Power; Siemens-Westinghouse / NREC; Energy Systems Services Corp.

Contract Amount: \$305,733

Match Funding: \$14,332

Principal Project Manager: Professor Scott Samuelson (949) 824-5468

Commission Contract Manager: Arthur J. Soinski (916) 654-4674

Project Description:

The purpose of this Agreement was to improve the understanding of the operation fuel cell systems and fuel cell/microturbine hybrid systems and to improve technology transfer capabilities at the National Fuel Cell Research Center (NFCRC). The development of new computer-based modeling tools addressed understanding the operation of the systems. The National Fuel Cell Research Center (NFCRC) implemented the following to address technology transfer:

- 1) Designed, constructed and operates a multi-function room at the NFCRC on the University of California, Irvine campus;

- 2) Established the Educational Facility for Ambient Air Monitoring, which consists of air quality monitoring instrumentation and computers for data collection and presentation; and
- 3) Established a web site to make information available.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by helping advance the development of clean and energy efficient distributed power generation technologies which will provide enhanced system reliability, highly efficient power generation, cleaner environment, and reduced cost.

Project Outcomes:

- Computer simulation models for three fuel cell and fuel cell/microturbine components were developed
 - models for a tubular solid oxide fuel;
 - a reformer that converts hydrocarbon fuels into a hydrogen-containing gas mixture to be used by the fuel cell; and
 - a microturbine.

A review was made of the models. Characteristics of those models were summarized, and advantages of the project's modeling methods and approach were described. These models can be used in the design of fuel cell system components, for the design of testing procedures, and in gaining better understanding of fuel cell system and microturbine operation and performance.

The technology transfer accommodations, ambient air monitoring workstation and website have been completed and are in routine use.

Project Status: The Draft Final Report has been submitted. The project was completed within budget. The computer modeling approaches used in this project are being applied to other fuel cell and fuel cell/microturbine systems in a subsequent Interagency Agreement (Contract #500-99-028).

Energy-Related Environmental Research Program Area

REGIONAL AMBIENT AEROSOL STUDIES (RAAS)

Contract #: 500-97-010-04

Contractor and Major Subcontractors: PG&E and Atmospheric and Environment Research, Inc.; Douglas Becker; Kelly Managerial Service

Contract Amount: \$399,000

Contractor Project Manager: Sam Altshuler
(925) 866-5879

Commission Contract Manager: Guido Franco
(916) 654-3940

Publication Number: P600-00-026

Project Description: This project allowed PG&E to continue providing technical expertise to the California Regional PM10/PM2.5 Air Quality Study (particulate matter less than 10 and 2.5 micrometer μm) size, respectively), a multi-agency study headed by the California Air Resources Board (CARB). Particulate matter (PM) smaller than approximately 2.5 micrometer (μm) tends to result from combustion processes including electric generating technologies, while PM larger than 2.5 μm results from sources such as windblown dust or seasalt. Significantly, it is PM2.5 that health experts consider most harmful to humans, because particles of this size can penetrate the body's natural defense mechanisms and reach most deeply into the lungs. For example, a recent comprehensive study has found that an increase of 1 microgram per cubic meter in particulates results in about 4 to 8 more deaths per 100,000 live births (infant mortality).

The San Joaquin Valley is not compliant with the State ambient PM air quality standard of 50-micrograms/cubic meter. Central California (including San Francisco and Sacramento) is not compliant with the federal ambient PM air quality standard of 150-micrograms/cubic meter. Therefore, compliance with the particulate matter standard, the ultimate objective of the large research program headed by ARB, will result in significant health benefits in California.

This project supports the PIER Program objective of:

- Improving environmental and public health costs/risk of California's electricity by improving the scientific understanding of the PM problem in Northern California. It emphasizes the quantification of emissions, the chemistry and physics involved in the transport of PM, the

formation and removal of PM and characterization of the meteorological conditions conducive to high concentrations

Proposed Outcomes:

- Allow PG&E to continue providing technical expertise to the California Regional PM10/PM2.5 Air Quality Study.
- PG&E involvement in technical and policy discussions.
- Revise and provide comments on technical documents prepared for the study.
- Participate in research activities culminating in technical papers presented at conferences; publication of technical papers.
- Document a field research program conducted in 1995.
- Prepare conceptual models for ozone and particulate matter formation in the central California region.
- Prepare specific analyses such as the role of volatile organic compounds (VOC) in the formation of secondary ammonium nitrate in the San Joaquin Valley.

Actual Outcomes:

- Participated in the design and planning of the Central California Ozone Study (CCOS) as it evolved.
- Identified the possibility of long-range aloft transport and the need for a mesoscale (regional) domain model that includes upwind metropolitan areas such as the San Francisco Bay Area, Monterey, and San Luis Obispo.
- Team member Dr. Paul Solomon co-authored and published a paper, *Modeling the Effects of Emission changes on PM2.5 Using the UAM-AERO Model in the South Coast Air Basin*, in the Proceedings of the PM2.5 Conference in January 1998.
- Two articles written as part of the 1995 Integrated Monitoring Study have been published in a special issue of *Atmospheric Environment*, a premier air pollution peer-reviewed publication.
- The article *Ozone Formation in the California San Joaquin Valley: A Critical Assessment of Modeling and Data Needs*, authored by Pun et al, has been submitted and accepted for publication in the Journal of the Air and Wastes Management Association.
- Developed a conceptual model for fall and winter PM concentrations in the San Joaquin Valley using the data gathered during the 1995 Integrated Monitoring Study. This model provides a better balance between meteorological and chemistry in the analyses of PM episodes than previously developed models, allowing for increased accuracy in modeling PM concentrations.

- Developed a conceptual model, incorporating the physical dynamics and chemistry of O₃ formation in the San Joaquin Valley.
- Developed and used a box model to investigate the response of PM nitrate to reductions in precursor emissions within the San Joaquin Valley.
- Found that the formation of nitric acid and particulate nitrate is sensitive to oxidants and to volatile organic compound emissions during the fall and winter.

This project is expected to continue through 2003. The overall study headed by the CARB has produced a number of conclusions including:

- The merits of detailed and complex analyses at fewer selected sites relative to less detailed measurements at more sites;
- The role of fog in PM formation and removal;
- The influence and regional extent of ammonium nitrate on wintertime PM formation;
- The degree that PM studies in one or two urban areas can be translated to other urban areas in the Central California region; and
- The degree to which residential wood burning is an important contributor to ambient PM.

BIRD STRIKE MONITOR

Contract #: 500-97-010-05

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$100,000

Contractor Project Manager: Sheila Byrne
(510) 866-5987

Commission Contract Manager: Linda Speigel
(916) 654-4703

Publication Number: P600-00-027

Project Description: The purpose of this project was to develop an efficient and cost-effective system to detect electric power-disrupting bird collisions with powerlines using a wire-trip mechanism. This system is designed to provide power line owners with the tools necessary to identify the power lines responsible for multiple bird collisions, without spending excessive time or money for unreliable or labor intensive reconnaissance. Once the power lines with high number of bird strikes are identified, powerline owners can then initiate mitigation strategies to reduce collisions. The Bird Strike Monitor can be used by all utilities and applicable regulatory agencies to identify and mitigate power lines responsible for multiple bird collisions.

In locations that receive high use by migratory waterfowl, collisions with power lines can result in high bird mortalities, which is in violation of the Migratory Bird Treaty Act. There

are numerous documented cases where listed species, such as the bald eagle and sandhill crane, have been killed as a result of collisions with power lines. Although collisions are frequent, they are often difficult to detect or are in remote locations. Current methods used to identify lines responsible for killing birds and to determine actual numbers of bird mortalities are labor intensive and unreliable. It is cost prohibitive to monitor the several thousand miles of power lines in the State and birds that have been electrocuted are often quickly removed by other wildlife before they can be detected. Furthermore, these bird collisions can cause expensive power outages or damage equipment. With the development of the Bird Strike Monitor, it may be possible to both decrease the number of bird-kills and power outages.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by providing information to reduce bird mortality associated with powerline collisions; and
- Improving the reliability/quality of California's electricity by reducing bird-related power outages.

Proposed Outcomes:

- Develop an affordable, reliable and proven device to detect bird collisions with electrical transmission and distribution wires.
- Help identify locations along transmission and distribution lines with high incidence of bird collisions.
- Modify transmission and distribution lined to reduce collision risk.
- Help utilities comply with applicable laws such as the Migratory Bird Treaty Act, state and federal Endangered Species Acts, and the Bald Eagle Protection Act.
- Reduce the incidence of temporary power outages.
- Design specifications of the Bird Strike Monitor will be documented sufficiently for manufacture, once the prototype has been deemed cost effective and reliable.

Actual Outcomes: Results of tests on the Bird Strike Monitor and design specifications are due in March 2000. Copies of the final report will be available to interested parties. A final meeting will be scheduled to discuss the next steps that should be taken concerning the continued advancement of the Bird Strike Monitor.

AVIAN POWERLINE INTERACTION COMMITTEE

Contract #: 500-97-010-06

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$40,000

Contractor Project Manager: Sheila Byrne
(510) 886-5987

Commission Contract Manager: Dick Anderson
(916) 654-4166

Publication Number: P600-00-028

Project Description: This project developed a course on reducing bird electrocutions and electric power disruptions associated with bird collisions with powerlines as part of PG&E's involvement in the Avian Powerline Interaction Committee (APLIC). The APLIC is an internationally recognized organization with approximately a dozen utilities, as well as the U.S. Fish and Wildlife Service and the Audubon Society as members. It is dedicated to developing methods to mitigate the impact of powerlines on birds. Bird collisions with powerlines result not only in transmission line outages, but also harms or kills rare and endangered species.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing interested parties with current technical information on how to reduce bird collisions with powerlines, thereby lessening or preventing power outages resulting from these collisions; and
- Improving environmental and public health costs/risk of California's electricity by providing information to reduce bird mortality associated with powerline collisions.

Proposed Outcomes:

- Develop a course on reducing bird electrocutions and electric power-disruptions associated with bird collisions with powerlines as part of PG&E's involvement in the Avian Powerline Interaction Committee (APLIC).

Actual Outcomes:

The short course, entitled, "Reducing Bird Collisions and Electrocutions," was held in May of 1998 at PG&E's Livermore Training Center. The short course provided an excellent forum for information exchange regarding causes and solutions for many types of bird electrocution and collision fatalities and associated power outages. Measures presented to reduce bird electrocutions included special insulation for potential electrocuting contact points and using an electrocution-proof configuration design in the construction of new powerlines. Measures discussed to reduce collisions included avoiding high bird use areas in siting of new powerlines and attaching various shaped devices (bird flight diverters) in order to alert birds to the hazard and allow them to avoid the line. Information was distributed to course attendees that will allow them to evaluate existing structures and recommend measures, as needed, to decrease adverse bird interactions with utility structures. The short course was well attended and received high marks by attendees.

FOOD SERVICE TECHNOLOGY CENTER

Contract #: 500-97-010-07

Contractor and Major Subcontractors: Pacific Gas and Electric (PG&E) and Fisher-Nickel Inc.; Fisher Consulting; Food Service Technology Center.

Contract Amount: \$350,000

Contractor Project Manager: Grant Brohard,
(925) 866-5713

Commission Contract Manager: Dr. Obed Odoemelam,
(916) 654-4171

Publication Number: P600-00-029

Project Description: This purpose of this two-part project was to establish a standard method for measuring emissions from commercial kitchens, and methods for reducing such emissions within the industry. The second part is aimed at establishing industry-wide design guidelines for achieving and maintaining optimum performance and energy efficiency in commercial kitchen ventilation systems. This project is conducting this research in response to the growing concern about the impact of emissions from the large number of commercial kitchens in California,

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by identifying ways to optimize the energy used for ventilation in commercial kitchens and reducing the health risks associated with emissions from these kitchens.

Proposed Outcomes:

- Maximize energy efficiency in commercial kitchen ventilation systems (CKV) in a way that will maintain the health and safety functions of the CKV system.
- Develop uniform test methods for characterizing emissions with regard to composition and major sources.
- Develop effective emission control approaches.
- Provide information for kitchen designers, mechanical engineers, food service operators, property managers, and maintenance people about achieving and maintaining optimum performance and energy efficiency in CKV systems.
- Provide information applicable to new construction and, in many instances, retrofit construction;
- Disseminate research through workshops and publications for the benefit of the industry and regulatory agencies concerned about these emissions.
- Develop industry-wide guidelines for designing, installing and operating ventilation systems in terms of health and safety, effectiveness and energy efficiency.

Actual outcomes:

Testing portion of the project (instrument calorimeters for

particulate matter and for heat gain measurement) was completed. These tests were conducted to establish a site for future testing purposes.

- Two new approaches to minimize emissions were developed, tested and evaluated. The first approach uses grease extractors to minimize emissions during the cooking process. The second approach uses catalysts in hoods for the removal of Particulate Matter resulting from the cooking process. Both of these emission control approaches were determined to be successful and have the potential for future use in the food service industry.
- A workshop on emissions measurement and control was held for the food service industry in San Francisco. The purpose of the workshop was to establish emission factors used for measuring emissions from commercial kitchen ventilation systems (CKV) systems. Designers and manufacturers from all over the country participated in this conference. Workshop proceedings were provided to interested parties;
- A Commercial Kitchen Ventilation System Performance Evaluation and Optimization workshop was held to demonstrate the methods developed to evaluate the efficiency of CKV systems. A report on the evaluation methods was prepared and made available to interested parties.
- A computer model designed to conduct cost assessments for commercial kitchen ventilation systems was developed and made available for industry-wide use. This model is designed to consider specific conditions and needs for individual commercial kitchens and allow for cost-effective CKV system designs.
- A draft of industry-wide guidelines for designing, installing and operating ventilation systems in terms of health and safety, effectiveness, and energy efficiency has been completed, but because of unexpected circumstances, a no-cost time extension to complete the final guidelines was requested and granted.
- Final report is expected January 2000 and will be available to interested parties from the contract managers.

WILDLIFE INTERACTIONS WITH UTILITY FACILITIES

Contract #: 500-97-010-08

Contractor and Major Subcontractors: Pacific Gas and Electric with Colson and Associates

Contract Amount: \$130,000

Contractor Project Manager: Mark Dedon
(510) 866-5829

Commission Contract Manager: Rick York
(916) 654-3945

Publication Number: P600-00-030

Project Description: The purpose of this project was to analyze products that reduce or prevent wildlife interactions, and resulting electrocutions and power

outages, with powerlines and power facilities. Distribution line add-on insulation and perch deterrent products that were added to distribution line power poles were analyzed to evaluate their durability and effectiveness.

This research project also evaluated the applicability and effectiveness of a geographic information system (GIS) model that would allow Pacific Gas and Electric (PG&E) to plan future electrical facility upgrades to reduce wildlife electrocutions and associated power outages. The GIS model is designed so it can also help predict "high risk" areas so new distribution lines and existing distribution line upgrades and designed so wildlife electrocution-related power outages are minimized. The GIS model was also developed in response to a 1994 settlement agreement between PG&E and the U. S. Fish and Wildlife service that arose after citations were issued to PG&E for the electrocutions of several Swainson's hawks, a State-protected species. Birds and other animals are the fourth leading cause of electric distribution outages in the PG&E system.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by improving current systems and technologies that prevent bird electrocutions caused by powerlines; and
- Improving the reliability/quality of California's electricity by reducing bird-related power outages.

Proposed Outcomes:

- Conduct research to evaluate the durability of specialized add-on insulation products and perch deterrent products installed in the field to reduce wildlife electrocutions and resulting outages. Based on preliminary laboratory tests conducted by PG&E during 1996-97, some insulation products are susceptible to degradation caused by various environmental factors such as moisture, sunlight, contaminants, etc. Some materials deteriorated quickly in laboratory tests and PG&E has recovered some products that have deteriorated in the field. This research was to examine the condition of various products installed in the field and installation procedures as appropriate.
- Address the usefulness of the geographic information system (GIS) model that incorporates the PG&E electrical distribution network and predictable wildlife resources to reduce the risk for wildlife electrocutions/collisions and outages on selected circuits. The GIS model was developed by PG&E in 1997 to aid in predicting areas susceptible to wildlife interactions. Electric planners and engineers believe a GIS system could improve system reliability when used for planning new circuits or upgrading existing circuits.

- Evaluate the GIS system in selected PG&E Divisions to obtain data on its usefulness. The merits of this system will be shared with other utilities to determine its applicability outside the PG&E service area.

Actual Outcomes:

Wildlife-Protective Devices

Objective:

- To better understand the expected life span of wildlife-protective devices in the field.

Outcomes:

- Based on the limited sample of protective devices observed, approximately 15 percent showed a degree of degradation that is likely to reduce their performance.
- Approximately 65 percent of the poles observed had wildlife protective devices that were not installed according to manufacturer recommendations or PG&E Engineering Standards. Installations were incomplete or improperly executed.
- While PG&E cannot say that improper or incomplete installation practices or degrading devices are the reason wildlife-caused outages continue to trend up in most PG&E divisions, it is likely they result in providing a risk for future outages.

Geographical Information System (GIS)

Objective:

- To implement the GIS developed in the pilot study throughout PG&E's service territory.

Outcome:

- The GIS system is now being used for a selected PG&E service territory.

Objective:

- Encourage use of the GIS by planners to better design new circuits in areas vulnerable to wildlife-caused outages.

Outcome:

- The project benefits from the use of PG&E's Intranet Map Server with centralized data. PG&E distribution planners are gradually discovering its usefulness in the design of new circuits and upgrades to existing circuits.
- Currently, GIS training is in high demand and user feedback is extremely positive.

Objective:

- Develop a risk model that indicates "high risk" areas where birds are more vulnerable to electrocution within PG&E's service area.

Outcome:

- The GIS provides the required risk model to comply with the PG&E/U.S. Fish and Wildlife Service settlement agreement.

Objective:

- Demonstrate that a GIS can be created to plan and build

a reliable electrical system that is less likely to have wildlife-related power outages.

Project Outcome: The PG&E project manager is available to demonstrate the GIS capabilities, discuss how the GIS was created and other sources of GIS/map information, and advise others how to design a similar system.

TRENCHLESS BURIAL EQUIPMENT

Contract #: 500-97-011-01

Contractor: San Diego Gas and Electric (SDG&E)

Contract Amount: \$130,000

Contractor Project Manager: Tamme Candelaio
(415) 973-8873

Commission Contract Manager: Ellen Townsend-Smith
(916) 654- 4170

Publication Number: P600-00-032

Project Description: The purpose of this project was to develop three time- and cost-saving technologies that will allow utilities to construct and maintain underground electrical distribution facilities. Remote sensing and detection equipment would be developed that improves the utilities' ability to service existing underground facilities and improves the current underground tunnel boring technologies.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by developing technologies that will allow utilities to reduce power outages and minimize the impact of such outages when they occur.

Proposed Outcomes:

- Develop a wireless fault indicator which would allow SDG&E crews to locate cable faults with a hand-held radio device rather than the conventional method of physically opening vaults to inspect fault switches;
- Develop and demonstrate SafeNav, a device for detecting and avoiding underground obstacles before collision during boring; and
- Develop a digital imaging system designed to improve the productivity and safety during inspection and inventory of underground distribution facilities.

Actual Outcomes:

- The Radio Based Fault Indicator (RBFi), a wireless radio-based fault indicator technology would allow crews to locate underground cable faults with a hand-held radio device, instead of the conventional manual way by physically opening vaults to inspect fault switches. A RBFi unit is installed within a manhole or underground vault.

During a power outage, utility personnel drive to the vicinity of the suspected fault, and poll (query) the Fault Indicator unit with a hand held reader that displays the indicates the condition of the fault. In early field-testing, 40 units were installed and tested by field crews at SDG&E. Several of the units failed because of moisture (or other contamination) intrusion in the battery case. Although field-testing demonstrated that the concept is technically valid, financial constraints prevent the contractor from pursuing design modifications. These issues are not deemed insurmountable and further funding is under consideration because of anticipated benefits in the areas of labor reduction, timesaving and improved system reliability, and personnel safety by avoiding having to physically open vaults.

- SafeNav, an underground horizontal drilling technology, detects underground obstacles and notifies the driller by alarms when obstructions are located within the bore path. SafeNav is designed to minimize damage to existing underground utilities and lower the occurrence of outages and associated safety hazards. Under this project, preliminary field-testing was completed and necessary design modifications developed. The results of these tests suggest that SavNav could improve safety, reduced drilling costs, result in faster installation time, and less disruption to consumers. If successfully commercialized, anticipated savings from the system are estimated to exceed \$300,000 annually, when comparing actual horizontal drilling to open trenching costs in a typical fiscal year.
- A Digital Inspection System (DIS) would allow access to underground facilities through an existing orifice on a manhole or handhole cover. A probe is placed into the vault to image the surrounding walls thus, mapping the vault configuration. The Digital Imaging Systems enables one person to perform the inspection, resulting in substantial savings in labor costs and reduced exposure to hazardous conditions. In conventional methods, entry to subsurface structures for inspection requires elaborate procedures to render the spaces safe. This includes water-pumping and atmosphere purging, involving crews of at least three people. Under this project, a design analysis was completed to define parameters for hardware selection. Bench scale testing identified a number of engineering issues including maintaining spatial orientation and visual resolution. These issues will be addressed in the next phase of the project.

WATER AND WASTEWATER ELECTROTECHNOLOGIES

Contract #: 500-97-012-01

Contractor and Major Subcontractors: Edison Technology Solutions (ETS) and Metropolitan Water

District; Orange County Water District; Electric Power Research Institute (EPRI)

Contract Amount: \$410,000

Contractor Project Manager: Lory Larsen (626) 633-7161

Commission Contract Manager: Wendell Bakken:
(916) 654-4042

Publication Number: P600-00-010

Project Description: The purpose of this project was to develop electrotechnologies which can produce new supplies of reliable and affordable drinking water, reduce electrical use to deliver and treat that water, and reduce the environmental problems created by current treatment and transport processes.

This project supports the PIER Program objective of:

- Improving environmental and public health costs/risk of California's electricity by possibly eliminating some conventional, chemically-intensive water treatment techniques and by helping to avoid transfers of water from environmentally sensitive areas in northern California to southern California.

Proposed Outcomes:

- Demonstrate Colorado River Water (CRW) salinity reduction measures using reverse osmosis (RO) and capacitive deionization (CDI) with carbon aerogel.
- Demonstrate the use of pulsed UV for disinfection and membrane biofouling control.
- Investigate the formation and control of bromate during ozonation.
- Study the disinfection of reclaimed wastewater with UV.
- Evaluate the performance of low-pressure membranes.
- Demonstrate that high-energy injection (E-Beam) is an effective alternative for water treatment.

Actual Outcomes:

- Both conventional treatment with and without ozone and biofiltration produced an effluent water quality suitable for use with RO. Significant energy savings can be realized with the use of ultra-low-pressure RO membranes over the previous generation of low-pressure RO membranes; however, large diameter RO elements are required for membrane technology to be implemented on a large scale. Carbon aerogel CDI technology has great potential, but the technology requires more development. Future CDI evaluations should be conducted at bench scale.
- Pulsed UV disinfected up to 99.99 percent of targeted virus and bacterial and would be significantly less costly than ozone or membrane Cryptosporidium reduction technologies. This technology could be an additional barrier to pathogenic organisms in drinking water treatment.

- Lowering pH before ozonation was effective in reducing bromate formation, but the technology is expensive compared to chlorination because of the large chemical dosages of acid required for pH control. Ammonia is a promising bromate control strategy for the Colorado River water at ozone doses required for enhanced *Cryptosporidium* disinfection. Hydrogen peroxide is not an effective bromate control strategy at the ozone doses required for 90 percent inactivation of *Cryptosporidium*.
- Ultraviolet disinfection is a viable alternative to adding chlorine to wastewater in the presence of ammonia for disinfection of reclaimed wastewater for non-potable reuse, and UV is much more effective in destroying bacteria. A 99.99 percent inactivation of indigenous coliphage and a 99.99 percent virus inactivation at the pilot plant was achieved.
- Ease of reclaiming water decreased as the quality of the feedwater decreased. Generally, microporous membrane permeability decreased as the concentration of suspended solids and biochemical oxygen demand in the feed water increased. Biological Oxygen Demand (BOD) can be used as a measure of the extent to which the water is polluted with organic compounds.
- High energy electron beam injection is an effective alternate water treatment method by meeting or approaching Maximum Containment Levels (MCLs) on a variety of priority contaminants. Additionally, costs to install and operate the system are competitive and potentially much lower than conventional and other emerging alternates and treatment on MDMA, an organic carcinogenic contaminant, showed effective removal rates at costs lower than existing chemical destruction technologies.

HABITAT AND SPECIES PROTECTION

Contract #: 500-97-012-05

Contractor and Major Subcontractors: Edison Technology Solutions (ETS) and Electric Power Research Institute (EPRI); Ed Almanza and Associates; University of California, Irvine; Premier Temporary Service; Bio Resources Consulting; Positive Systems; Applied Biomathematics

Contract Amount: \$525,000

Contractor Project Manager: Dan Pearson
(626) 302-9562

Commission Contract Manager: Marc Sazaki
(916) 654-5061

Publication Number: P600-00-014

Project Description: The goal of this project was to minimize raptor mortality (and resulting electric power disruptions) associated with power lines by identifying where and why this mortality occurs and then developing

recommendations to minimize these impacts. Research was also conducted to determine methods for minimizing the impacts of power facility construction on sensitive species and habitats.

This project addresses the PIER program objectives of:

- Improving environmental and public health costs/risk of California's electricity by developing methods to minimize the environmental impact of power facilities on sensitive species and habitats; and
- Improving the reliability/quality of California's electricity by reducing bird-related power outages.

Proposed Outcomes:

- Reduce raptor mortalities caused by electrocution at power lines and power outages associated with such instances system-wide. Consequently, raptors would be protected and power line system reliability would be improved.
- Develop protocols to characterize and monitor critical California habitat types to avoid or minimize impacts through multiple species habitat conservation research and habitat evaluation. Given the development of these protocols, fewer habitat and species issues should arise.
- Apply developed models in future planning efforts to allow for more comprehensive validation of new habitat and species protection approaches.

Actual Outcomes:

- Produced a series of reports that present reliable and cost-effective methods for identifying areas with recurring raptor electrocution problems. Appropriate mitigation actions can be applied in problem areas where found.
- A series of reports have been completed that describe advanced aerial mapping techniques that can be used for characterization of plant species composition and abundance in sensitive habitats that may be used by a multitude of wildlife species, such as the legally protected California gnatcatcher. In addition, models that estimate extinction rates for threatened and endangered species are described, including the California gnatcatcher and the desert tortoise. These methods are available for use to minimize potential impacts associated with electricity development in California.
- The reports will soon be made available on the Commission's Web site; for now they are available from the Project Contract Managers.

DESERT AND MOUNTAIN AIR TRANSPORT

Contract #: 500-97-012-06

Contractor and Major Subcontractors: Edison Technology Solutions with Electric Power Research Institute (EPRI); and South Coast Air Quality Management District (SCAQMD)

Contract Amount: \$825,000

Contractor Project Manager: Vincent Mirabella
(626) 302-9748

Commission Contract Manager: Tuan Ngo
(916) 654-3852

Publication Number: P600-00-015

Project Description: The purpose of this project was to develop and apply new methods for characterizing and quantifying the regional transport and chemistry of visibility-impairing emissions (haze) leading to improvements in regional visibility in California. (Haze refers to atmospheric moisture, dust, smoke and vapor suspended to form a partially opaque visual condition). The modeling tools and methods developed under the DMAT Project will provide focus on the special visibility problems facing several Class I areas located in California as well as assist in developing assessment technologies for addressing the visibility problems facing urban areas of California.

This project supports the PIER program objective of:

- Improving environmental and public health costs/risk of California electricity by providing the knowledge of the transport and chemistry of visibility-impaired emissions to address the protection of visibility at mandatory federal Class-I areas in California and elsewhere.

Proposed Outcomes:

- Interpret inert tracer data released as part of the project to characterize the transport of emissions from various regions of the western United States;
- Assess the reliability of currently available regional transport and chemistry visibility models; and
- Develop "conceptual models" to provide a fundamental understanding of the transport and chemical mechanisms that cause western visibility impairment.

Actual Outcomes:

- The DMAT study concluded that there is no direct relationship linking the emissions from a particular source to the regional visibility impairment in the Grand Canyon National Park.
- The study concluded that the visibility impairment problem was caused by a combination of many industrial sources including those in Southern California, Northern Mexico and Las Vegas.
- The analysis of inert tracer data is inconclusive and did not establish the reliability of current regional transport and chemistry visibility models. This is likely due to different mechanisms of sulfate formation chemistry in the clouds assumed in each model.
- CALMET was determined to be the most successful

model among the models used to generate the wind fields that affect the transport of air pollutants.

- A conceptual model was developed and evaluated for simulating the formation of aerosols and photochemical ozone from a point source. Further testing is needed prior to the model being used on an operational basis.

FORMATION OF NO_x IN INDUSTRIAL GAS BURNERS

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute for Energy Efficiency (CIEE) and University of California, Irvine; Combustion Lab; Scott Samuelsen

Contract Amount: \$335,000

Contractor Project Manager: Jim Cole (510) 486-4123

Commission Contract Manager: Matt Layton
(916) 654-3868

Publication Number: P600-00-009

Project Description: The purpose of this project was to develop technologies (and associated scientific and applications-oriented knowledge) to attain and maintain energy-efficient operation of natural gas industrial burners and stationary gas turbines with ultra-low emissions of nitrogen oxides (NO_x). The core component of this project will be a closed-loop combustion control with advanced sensors, including field applications applied to industrial burners and boilers. The high temperature and boiler elements of this project, funded by Southern California Gas, Maxon and Coen, involve laboratory field testing and other technology transfer activities that interact synergistically with the core component.

Low emissions technologies are driving the development of new generation stationary power sources. The next generation industrial burners and stationary gas turbine combustors will be required to maintain extremely low levels of nitrogen oxides (NO_x) and carbon monoxide (CO) emissions, previously thought unattainable. Current state-of-the-art is to use back-end clean up of the exhaust stream with selective catalytic reduction (SCR) or a similar technique. This method, although effective, is costly. Alternatively, burner and gas turbine combustor manufacturers are striving to reduce the pollutants at the source by adopting a lean-premixed or partially-premixed fuel and air strategy; the challenge with lean premixed systems is that CO can increase and stability can decrease along with the reduction in NO_x.

This project supports the PIER Program objective of:

- Improving environmental and public health costs/risk of California's electricity by maintaining the energy efficiency and ultra-low emissions achieved in natural gas industrial burners and stationary gas turbines.

Proposed Outcomes:

- Further develop the active control system on a boiler burner (the first demonstration occurred through the CIEE core program).
- Proof-of-concept of the active control on a gas turbine, both applications targeting the energy/electrical production market. The core component is a closed loop combustion control with advanced sensors, including demonstrations applied to industrial burners and gas turbines.
- Identify fast feedback sensors.
- Determine the suitability of these fast sensors for industrial burners and gas turbine applications.
- Upgrade the active control software for ease-of-use and fast feedback capability.
- Refine the use of the fast sensors and new software on industrial burners.
- Demonstrate the fast sensors and new software on a gas turbine combustor.
- Transition the experimental results to the combustion community.

Actual Outcomes:

A comprehensive active control strategy was successfully demonstrated for industrial gas burners and stationary gas turbines during this one-year project.

- The fast sensors that were investigated and selected for trials were fiber optic collection of reaction chemiluminescence, an acoustic microphone, and a piezoelectric, dynamic-pressure sensor.
- The active control computer system consisted of commercial software and hardware (National Instruments LabView and data acquisition boards) in conjunction with simple optimization techniques.
- Control of the combustion processes was achieved using mass flow controllers to optimize the fuel injection and airflow at different operating conditions.
- A second-generation active control system using fast sensors was demonstrated on two different sized industrial burner systems and a gas turbine combustor.
- Transition of the results to the combustion community occurred via three presentations of the project results at two different combustion conferences and through personal interaction with industrial burner and gas turbine manufactures at the conferences.

The successes of this research are encouraging and timely for the electric industry in California. Central station and small, distributed generators will compete in the deregulated electricity market, which could mean constant cycling of firing rate while still complying with some of the strictest air pollution regulations in the country.

TARGET 97, GROUNDWATER AND COMBUSTION BY-PRODUCTS MANAGEMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Diversified Program; Ishwar Mururka; Stephen D. Mueller; American Electric Power Service Co; Battelle Pacific Northwest Laboratories; META Environmental Inc; Natural Resource Technology Inc; Ohio Edison Company; Science & Technology Management Inc; Southern Company Services Inc; Tennessee Valley Authority; Tetra Tech Inc; University of North Dakota; Wisconsin Electric Power Company

Contract Amount: 1999: \$312,000

Match Funding: 1999: \$2,387,775

Contractor Project Manager: Ken Ladwig
414) 785-5952

Commission Project Manager: Tom Tanton

Commission Contract Manager: Gary Klein
(916)653-8555

Project Description: The purpose of this project is to deliver R&D results on leaching, attenuation, and fate of metals from combustion by-products disposal facilities to strengthen the basis for cost-effective regulations. Leaks and releases of fuel oils at power plants have resulted in contamination of subsurface soils and groundwater, requiring innovative approaches for remediation. Similarly, the storage of coal on land has resulted in the generation of leachates containing metals and acidity which are subject to surface and subsurface migration. This EPRI target also produces innovative methods for managing wastes and restoring soils and groundwater contaminated by sources other than power plant by-products. Databases and fate and transport software will be developed or enhanced to enable members to cost-effectively manage contaminated sites while protecting the surrounding environment.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by determining cost-effective methods for remediating contaminated land and groundwater; and
- Improving the environmental and public health costs/risks of California's electricity by effectively cleaning up the environment, thereby reducing human and ecological exposure to chemical contaminants.

Proposed Outcomes:

1. Provide scientific and engineering knowledge (software, information, manuals, and improved insights) for the management of chemicals in disposal sites, landfills, impoundments, and power plant storage facilities.
2. Provide characterization and remediation methods, information, and tools to improve soil and groundwater quality.
3. Design liners and barriers for effective groundwater protection.

4. Develop fate and transport analysis tools to support removal of contamination from groundwater.

Actual Outcomes:

1. Management of chemicals.
 - A report was published on the co-management of mill rejects at coal-fired power plants.
 - Proceedings were published from the 13th International Symposium on Use and Management of Coal Combustion Products.
2. Improvement of soil and groundwater quality.
 - Version 2.5 was released of the MANAGES database management system for the storage, analysis, and reporting of water quality data.
 - A report was published on groundwater quality at power plants in West Virginia.
 - A report was published on re-vegetation of a co-managed utility waste disposal area.
 - A report was published on restoration of eroded land using coal fly ash and biosolids.
 - A report was published on utilization of coal combustion by-products in agricultural and land reclamation.
 - A report was published on land application uses for dry flue gas desulfurization by-products.
3. Findings were published of an evaluation of an Ecolotree CAP for closure of coal ash disposal sites.
4. A report was published on the environmental distribution of petroleum hydrocarbons at a utility service center.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

TARGET 107 PLANT MULTIMEDIA TOXICS CHARACTERIZATION (PISCES)

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Carnegie Mellon University; CH2M Hill, Inc.; Fossil Energy Research Corp.; METCO Environmental Inc; Mostardi-Platt Associates Inc; Quality Associates Int'l Canada Ltd.; Radian International LLC; RMB Consulting and Research Inc; Tennessee Valley Authority; TRW Inc; U S Geological Survey; University of Louisville; University of North Dakota; Bevilacqua Knight

CEC Project Amount: 1999: \$276,000

Match Funding: 1999: \$3,849,810

Contractor Project Manager: Babu Nott (650) 855-7946

Commission Project Manager: Joe O'Hagan (916)653-1651

Commission Contract Manager: Gary Klein (916)653-8555

Project Description: The purpose of this project is to measure and characterize potentially toxic substances in

air, water, and solid waste streams emanating from electric power plants. This effort is critical for managing toxic emissions and discharges in an environmentally acceptable and cost-effective manner. EPRI's PISCES (Power Plant Integrated Systems: Chemical Emissions Studies) project was launched in 1988 to collect and analyze power plant trace substances data for multimedia discharge/emissions implications. PISCES data also enable meaningful analysis of the health risks posed by power generation emissions and discharges. To date, the data generated by the PISCES project have been provided to the U.S. EPA (in EPRI's Synthesis Report) and used in EPA's report to Congress on hazardous air pollutants. The tools provided in this target can be utilized to assess opportunities for pollution prevention, to evaluate the impact of alternative strategies, and to establish benchmarks for pollutant inventory and tracking. In addition, work will be initiated to address material balance studies involving such key elements as carbon, sulfur, and nitrogen that are associated with such issues as global climate change, acid deposition, and coastal water nitrification.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing:
 - Meaningful analysis of the health risks posed by power plant emissions and discharges;
 - Assessment of opportunities for pollution prevention and of impact of alternative strategies;
 - Establishment of benchmarks for pollutant inventory and tracking; and
 - Research results on global climate change, acid deposition, and coastal water nitrification.

Proposed Outcomes:

1. Improve the PISCES modeling capabilities by conducting characterization field tests to accurately measure multimedia emissions, upgrading the database, and expanding the chemical assessment model.
2. Provide accurate characterization data on solids (including fuels, reagents, by-products, and solid wastes) to support cost-effective, environmentally acceptable power plant operation and management.
3. Determine more accurate and sensitive methods for analyzing organics such as dioxins to avoid "non-detects," especially if the thresholds for the release of these chemicals are significantly lowered (for example, for TRI reporting).

Actual Outcomes:

1. Improve PISCES modeling capabilities.
 - PISCES: Power Plant Chemical Assessment Model, Version 3.03 software was developed.

- Organizations were surveyed to develop a Version 4.0 of the PISCES model to improve usability and speed, and incorporate enhancements for the Toxics Release Inventory.
- A comprehensive characterization was conducted of wastewater at a zero-discharge fossil-fuel-fired power plant, and a water characterization field study report was published.
- The Fourth International Conference on Managing Hazardous Air Pollutants was held with EPRI sponsorship, and a proceedings of the conference was published.
- A scoping study was conducted, and a report published on the American Eel (*Anguilla rostrata*).

2. Advanced methods were developed for sampling and analyzing different species of trace metals such as mercury and nickel. Methods were developed for measuring nickel subsulfide emissions from oil-fired power plants, nickel speciation measurements at oil-fired power plants, and mercury speciation stack sampling.
3. A study was conducted of toxic emissions from a gasification-combined cycle (GCC) power plant.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

Strategic Energy Research

ELECTRIC SYSTEM SEISMIC SAFETY AND RELIABILITY

Contract: 500-97-010

Contractor and Major Subcontractors: Pacific Gas and Electric Company and University of California, Berkeley Pacific Earthquake Engineering Research Center (PEER)

Contract Amount: \$1,000,000

Contractor Project Manager: Dr. William (Woody) Savage (415) 973-3116

Commission Contract Manager: Robert Anderson (916) 654-3836

Publication Number: P600-00-031

Project Description: The purpose of this project is to support several major research projects in the field of electric system seismic safety and reliability. Projects ranged from the shake table testing of electric bushings and the collection of soil data at existing substations, to the development of a rapid response, strong ground shaking contour map program and related strong ground motion attenuation curves. Some of the early products have already been incorporated by a major California utility in their risk management practices. This contract was extended through January 31, 2000, due to the interruption of research report preparation by investigators assigned to assess damage in Turkey after the August 17, 1999, magnitude 7.4 Kocaeli earthquake.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing the vulnerability of the electric transmission and distribution system due to damage caused by a major earthquake, continuation of power in an area affected by an earthquake and/or by the rapid recovery of the electric service. This rapid recovery will allow for a shortened interruption to emergency services and businesses due to the loss of electric power.

Proposed Outcomes:

- Improvements to installed utility equipment will be identified and tested, and the potential for future disruptions due to earthquake-induced damage can be reduced.
- Develop improved assessments of shaking-caused permanent ground deformation hazards in formats that the utility can directly use for evaluating electric system vulnerabilities.
- Examine the process of fire initiation during power

restoration following earthquakes to evaluate various means to reduce the risk of starting fires.

- Develop the capability to analyze data from distant seismographic instruments to accurately predict the pattern and severity of strong earthquake shaking anywhere in the state.

Project status: The project is on schedule, within budget and is expected to achieve the proposed outcomes.

DYNAMIC CIRCUIT THERMAL LINE RATING (DCTR)

Contract: 500-97-011

Contractor: San Diego Gas and Electric (SDG&E)

Contract Amount: \$110,000

Contractor Project Manager: Bill Torre (619) 696-4880

Commission Contract Manager: Linda Davis (916) 654-3848

Publication Number: P600-00-036

Project Description: The purpose of this project was to develop and demonstrate real-time transmission line ratings. DCTR uses equipment mounted on a transmission tower to monitor the line conductor tension and determine ground clearances and weather conditions to calculate the amount of current that can be transmitted in real time. This information is provided to system operators or engineers for their use in safe, reliable and economic system operation. Conventional transmission lines ratings have been established as static rating, which may be lower than the maximum capability of the conductor. By monitoring wind speed, conductor tension and solar heating, a real time line rating may be calculated that is closer to the maximum conductor capability.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity since using real time dynamic line ratings ensures reliability and quality by making sure that ground clearances are not exceeded thus avoiding contact and flashovers which cause power outages and voltage surges;
- Improving the energy cost/value of California's electricity by improving transmission line utilization to facilitate economic transactions and reduce costs as real time ratings allow greater power transfers on existing facilities than the static line rating;
- Improving the environmental and public health costs/risks of California's electricity by improving utilization of existing

transmission lines thereby avoiding the need for new lines and the associated environmental impacts; and

- Improving the safety of California's electricity by using real time information to make certain that ground clearance limits are not exceeded thus avoiding the risk of electrical shock and fires.

Proposed Outcomes:

- Increase transmission capacity on congested transmission lines to allow increased power transfers.
- Reduce use of expensive generators which "must run" due to transmission rating constraints.
- Promote the use of more economic generators to result in reduced energy system price for utility customers.

Actual Outcomes:

- The dynamic real time rating for the demonstration was up to 150 percent more than the normal rating at some times. From 9 a.m. through 5 p.m., the dynamic rating averaged a 75 percent increase in rating over the normal rating on that circuit.
- The real time rating also indicates that line ratings are sometimes reduced, and eliminates the risk of sagging the conductor to the point of contact thus preventing danger to the public.

SYSTEM STABILITY AND RELIABILITY: FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS) BENEFITS STUDY

Contract #: 500-97-011

Contractor: San Diego Gas and Electric (SDG&E)

Contract Amount: \$100,000

Contractor Project Manager: Abbas Abed (619) 696-2755

Commission Contract Manager: Linda Davis
(916) 654-3848

Publication Number: P600-00-037

Project Description: This project investigated the feasibility and benefits of implementing Flexible AC Transmission System (FACTS) devices on Extra High Voltage (EHV) electricity transmission lines to increase power transfer capability and electricity import capability. The use of Static Condensers (STATCON), Thyristor Controlled Series Capacitors (TCSC) and Static Var Controllers (SVC) were examined in this previous study.

To meet the forecasted future electrical load in California, either additional generation must be installed or import capability must be increased. FACTS technologies help improve power transfer, power quality and system control. FACTS technologies use high-speed, thyristor-controlled devices and advanced control concepts to allow loading lines to their thermal limits without compromising system

reliability. This study conducted detailed technical and economic studies to investigate the benefits of FACTS technologies for the SDG&E service territory.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by allowing operators to load lines to their thermal limits without compromising system reliability;
- Improving the energy cost/value of California's electricity by improving the efficiency of the power transfer capacity of the electricity transmission system; and
- Improving the environmental and public health costs/risks of California's electricity by improving the power carrying capability of the existing system thereby reducing the need for new transmission lines.

Proposed Outcomes:

- Conduct detailed technical and economical studies to investigate the benefits of Flexible AC Transmission Systems (FACTS) devices located in SDG&E's service territory. The study focus was on the potential benefits of existing and new FACTS devices in improving SDG&E's import capability.

Actual Outcomes:

- Preliminary studies show that facility overload and reactive power deficiency are the main problems associated with increasing SDG&E's import capability.
- FACTS technology can be used to mitigate both problems and could possibly increase SDG&E's simultaneous import capability by 300 MW by relieving line overloads and providing dynamic reactive power support.
- FACTS also could possibly increase non-simultaneous import capability by 250 MW by relieving line overloads and providing dynamic reactive power support.
- The system transfer capability increases can also be achieved through rearrangement of transmission circuits at lower cost than the FACTS technology.

PHASOR MEASUREMENT UNITS

Contract #: 500-97-012

Contractor: Edison Technology Solutions (ETS)

Contract Amount: \$150,000

Contractor Project Manager: Mohan Kondragunta
(626) 815-0507

Commission Contract Manager: Linda Davis
(916) 654-3848

Publication Number: P600-00-019

Project Description: This project demonstrated real-time monitoring and potential of future control of the Western Systems Coordinating Council (WSCC) electric power grid using Phasor Measurement Units (PMUs), which are low-

cost sensors that measure voltage, current phase angles and magnitudes that are time tagged for relative comparison between geographically distant locations in Southern California and Oregon.

The PMUs communicate real-time data to a Phasor Data Concentrator (PDC) at very high speed using communication systems from all the monitoring sites. The system will allow various energy control centers and systems to monitor the entire WSCC system and will help to provide information to prevent wide scale power outages. The project will develop a system to pool data from all major WSCC members and make it available to all participating members for post-disturbance analysis.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by allowing regional energy control centers and systems to monitor the entire WSCC system; and
- Improving the energy cost/value of California's electricity by reducing wide scale power outages.

Proposed Outcomes:

- Develop a system that facilitates real-time monitoring of regional transmission facilities.
- Low-cost sensors and software were to be developed for use with a high-speed communication system that allows utilities and eventually regulators to monitor the status of regional transmission and distribution lines.

Actual Outcomes:

- Two PMUs installed in Southern California Edison (SCE) with communication systems resulted in data collected at a very high speed from all the monitoring sites for viewing grid disturbance data of the Bonneville Power Administration in Oregon at SCE in Southern California.

USAT MOD-2

Contract #: 500-97-012

Contractor: Edison Technology Solutions (ETS)

Contract Amount: \$1,000,000

Contractor Project Manager: Bob Yinger (626) 815-0508

Commission Contract Manager: Linda Davis
(916) 654-3848

Publication Number: P600-00-020

Project Description: The purpose of this project was to promote development of the USAT satellite communications system to deliver high-reliability communications for utility supervisory control and data acquisition (SCADA) systems under all types of weather conditions. SCADA systems allow a utility to monitor and control its transmission and distribution system to insure

high reliability. Traditionally, communications was accomplished by leased or private telephone lines, microwave, fiber optic cable or radio. The use of satellite communications needs to be very cost effective in remote areas and capable of collecting high speed SCADA data from any location in California no matter how remote. This data would not be available if conventional communications technologies were used.

This SCADA data is valuable in insuring that the highest reliability is maintained for the California transmission and distribution systems by enabling real-time monitoring of system loading and quick execution of control commands during normal and emergency conditions. Because of the system's high reliability and "communications anywhere" capability, it is invaluable during major fires, storms and earthquake emergencies. Communications during these emergencies is valuable in locating problems, assessing damage and returning equipment to service quickly. The ULTRA-NET™ remote terminals are easily installed and can be in service within a few hours to help reduce restoration time after a catastrophic event.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing accurate electric grid monitoring information on power supply disruptions;
- Improving the energy cost/value of California's electricity by reducing maintenance costs and restoration time;
- Improving the environmental and public health costs/risks of California's electricity by eliminating the need for service vehicles to visit remote sites on a regular basis. [This will result in a reduction of over 3 million vehicle miles (250 to 500k miles per year) resulting in fuel conservation and a corresponding reduction in environmental pollution]; and
- Improving the safety of California's electricity by allowing communications to be restored quickly when the infrastructure for other systems has been damaged or during catastrophic events.

Proposed Outcomes:

- Deliver high-reliability data between SCADA systems of electrical transmission and distribution systems under all types of weather conditions using satellite communications that are cost effective in remote areas.
- Develop a satellite communications system capable of collecting high speed SCADA data from any location in California no matter how remote to make data available beyond that of conventional communications technologies and enabling real-time monitoring

Actual Outcomes:

- The system operated successfully, but more field

operation is required before it can be considered a commercial product.

- To increase the commercial potential of the system, the cost of the remote terminals needs to be reduced since many remotes and only one hub is required in a complete system.
- Restoration time for communication to remote areas can be greatly improved since conventional restoration can take days, while the restoration of communications with USAT is accomplishable within hours.

ENERGY SOURCE STABILIZER (ESS)

Contract: 500-97-012

Contractor: Edison Technology Solutions (ETS)

Contract Amount: \$250,000

Contractor Project Manager: Mohan Kondragunta (626) 815-0507

Commission Contract Manager: Linda Davis (916) 654-3848

Publication Number: P600-00-021

Project Description: This project developed and demonstrated an Energy Source Stabilizer (ESS) that functions through a generating machine governor or other electronics-controlled power device to stabilize electrical frequency oscillations between various areas. Inter-area oscillations can cause very wide spread and costly power outages that may last for many days. Control of these dynamic oscillations through the generating machine governors is more effective and inexpensive than the existing power system stabilizers that function through the generating machine excitation system. Once proven, the ESS units can be installed on all generating machines having state-of-the-art rapid response governors.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing the incidence of large-scale power outages; and
- Improving the energy cost and value of California's electricity by providing a low-cost means of improving system reliability.

Proposed Outcomes:

- Stabilize low frequency dynamic system oscillations by modulating the real power of generators, thereby improving system stability and reliability.

Actual Outcomes:

- Two Energy Source Stabilizers (ESS) were installed at Alamitos Generating Station in Southern California and ESS performance was monitored during system disturbances to validate the working of ESS.
- The ESS operated as expected to dampen oscillations

that otherwise may have increased to cause a widespread power outage.

- Multiple ESS units need to be installed throughout the Western Systems Coordinating Council (WSCC) system to achieve the reliability benefits possible with this technology. It is estimated that the increase in energy import capability due to the reliability improvements of installing ESS can save California electric customers approximately \$15-20 million per year.

SUBSTATION RELIABILITY

Contract #: 500-97-012

Contractor: Edison Technology Solutions (ETS)

Contract Amount: \$215,000

Contractor Project Manager: Alonso Rodrigues (626) 302-8423

Commission Contract Manager: Linda Davis (916) 654-3848

Publication Number: P600-00-022

Project Description: The purpose of this project was to develop an intelligent alarm analysis and diagnostics system, the Alarm Analyzer. The system simplifies thousands of pieces of information and alarms during an emergency condition, such as a regional system breakup due to a fault. In a matter of seconds, the operator is presented with only the relevant and highest priority information on system status and a recommended course of action. This compares to hours or days to do the same manually.

Voice data and command entry is established in control room consoles. During system disturbances, switching and other load and grid operations must be executed quickly and accurately. Speech recognition tools being adapted and evaluated through this project will free the operator from the keyboard to permit data entry and commands by voice. This project improves substation system efficiency, reliability and capacity and reduces operation and maintenance costs. This project helps electrical system operators to provide a much quicker response time during transmission system breakup and disturbance.

The Alarm Analyzer improves the accuracy of control room operator decisions by assisting in quickly identifying the type of fault and accurately identifying its location. This information is essential in reducing the amount of outage time and costs to the users and the utilities. Crews can be dispatched with the correct materials for repairs to the precise trouble location and system reconfiguration can be implemented immediately to restore service through alternate routes.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing restoration and fault analysis time from hours or days to minutes;
- Improving the energy cost/value of California's electricity by reducing operations and maintenance costs; and
- Improving the environmental and public health costs/risks of California's electricity by reducing the risk of operation mistakes during power disturbances.

Proposed Outcomes:

- Complete the initial stage of development of an intelligent alarm analysis and diagnostics system to automatically classify and filter the thousands of pieces of information and alarms generated during an abnormal event on the grid, such as a regional blackout caused by a fault.
- Investigate the feasibility of the Alarm Analyzer tool.
- Implement voice recognition technology and evaluate its benefits in the entry of data and commands into a computer or other device in control rooms and other applications.

Actual Outcomes:

- Southern California Edison (SCE) completed its objectives by developing the Alarm Analyzer tool, implementing voice recognition technology, and conducting successful demonstrations of each.
- Use of the Alarm Analyzer tool reduced the time required to produce an accurate diagnostic of an event from several hours or days to less than two minutes. These results are based on simulations of actual events occurring at the Dalton Substation.
- The voice recognition tools evaluated in this project resulted in a productivity increase of at least 200 percent in entering information into a computer file, with an accuracy rate greater than 97 percent. These results are based on a comparison between keyboard entry methods and voice input.
- Operations and maintenance costs are reduced by improving productivity through data entry and control of computers via voice. Dictating directly to the computer was found to improve productivity by at least 200 percent and greatly simplified multi-tasking for control room operators, line patrols, and office personnel.

DEVELOPMENT OF A COMPOSITE REINFORCED ALUMINUM CONDUCTOR

Contract #: 500-98-035

Contractor and Major Subcontractors: W. Brandt Goldsworthy & Associates, Inc.

Contract Amount: \$75,000

Match Funding: \$185,000

Los Angeles Regional Technology Alliance \$65,000

DOE-Energy Inventions and Innovations \$55,000

WBG&AI \$65,000

Contractor Project Manager: W. Brandt Goldsworthy
(310) 375-4565

Commission Contract Manager: Linda Davis
(916) 654-3848

Publication Number: P600-00-040

Project Description: The purpose of this project is to improve the reliability and capability of California's transmission and distribution system by developing a stronger and lighter conductor to replace these aging and overloaded power lines. Specifically, this project will develop a composite reinforced aluminum conductor (CRAC) to replace conventional conductors made from aluminum wires wrapped over a core of steel strands (called aluminum conductor - steel reinforced (ACSR) conductors). Many miles of California's overhead electricity transmission lines have reached the end of their service lives or are being stressed beyond their design limits due to load growth and heavy power transfers across longer distances. This technical development is very timely as the current age of transmission lines ranges from 30 – 70 years.

W. Brandt Goldsworthy and Associates, Inc. of Torrance, CA, with additional match-funding support from the DOE and private industry, is reconfiguring aluminum conductors around a lightweight composite strength member whose weight is approximately 25 percent of the traditional steel strength member. The resulting lightweight conductor can be optimized for reduced sag and increased ampacity. CRAC conductors can withstand adverse weather and high load conditions, thereby avoiding power outages caused by line sagging and swinging, high winds and ice buildup.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup;
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors;
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines; and
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

- Design, fabricate and test a robust, practical and cost-effective composite reinforced aluminum conductor.

- Target market price for CRAC is \$1.00 per product pound, which is approximately the cost of aluminum conductors which are steel reinforced.
- Five percent more electrical conductivity, compared to steel reinforced aluminum conductor
- Reduced mechanical elongation (line sag) at high operating temperatures
- 250 percent stronger than steel reinforced aluminum conductor
- 75 percent lighter than steel reinforced aluminum conductor

Actual Outcomes:

- Two CRAC, CRAC-121 (one-to-one) and CRAC-Advanced, were developed during this project. Both achieved:
 - Five percent more electrical conductivity than DRAKE.
 - A minimum of 40 percent more ampacity than DRAKE.
 - Twenty percent less mechanical elongation at ambient operating temperatures.
 - A 30 percent strength increase compared to DRAKE.
 - Only a 25 percent weight reduction was achieved and the objective of a 66 percent reduction was not met. In retrospect, this turned out to be an ill-posed objective because the maximum possible weight reduction, achieved by taking all the steel out of the DRAKE conductor, is only 33 percent.
- Splicing techniques were developed and demonstrated for both CRAC.
- A splicing tool was developed to splice the composite strength member.
- There were two very positive unanticipated outcomes.
 - CRAC conductors were found to operate 9 (CRAC-121) to 25 percent (CRAC Advanced) cooler than ACSR conductors.
 - Both conductor designs can carry optical fibers in the hollow center. When optical fibers are added, these conductors are called CRAC-TelePower.

TARGET 1 RESIDENTIAL HEAT PUMP TECHNOLOGY

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; D.W. Abrams, P.E. & Associates; P.C.; OG&E Electric Services Company; Oregon Department of Energy; Saturn Resource Management; Southern California Edison Co.

CEC Project Amount: 1999: \$293,697

Match Funding: 1999: \$1,129,818

Contractor Project Manager: Carl Hiller (530) 758-3035

Commission Project Manager: Bill Pennington

Commission Contract Manager: Gary Klein

(916) 653-8555

Project Description: The purpose of this project is to

support EPRI's continuing development of high-performance (energy efficient) heat pumps and their efforts to deliver quality data and services to invigorate the market. Working with manufacturers and research partners, EPRI is supporting production of climate-wise air and geothermal heat pumps, demonstrating heat pump applications, verifying performance and energy efficiency, and pursuing refinements to the "Insider" heat pump, a compact unit for multifamily and manufactured housing. This target also delivers products on duct system design and duct sealing technology to further reduce energy waste, and collaboration on a national technician certification program to address installation and customer satisfaction issues.

EPRI's collaborative program impacts technology development and heat pump infrastructure nationally. This, in turn, benefits California users to ensure a continued positive market environment for residential heat pumps. The Commission will receive technical information and persuasive promotional materials for local educational activities to stimulate residential customer's interest.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and enhancing the performance and efficiency of residential heat pump technology to reduce the energy needs for space heating and cooling applications; and
- Improving the environmental and public health costs/risks of California's electricity by reducing energy use, which in turn decreases power generation emissions, and by supporting the changeover from ozone depleting refrigerants to Zero Ozone Depletion Potential (ZODP) fluids.

Proposed Outcomes:

1. Provide tools to increase the use of Zero Ozone Depletion Potential (ZODP) Refrigerants.
2. Provide tools to increase the potential for the use of Air-Source Heat Pumps.
3. Provide information to support market-ready enhanced, integrated heat pumps.
4. Develop a Technician Certification program to improve the likelihood of proper heat pump selection and proper installation.
5. Supply information to increase the potential for use of Ground-Source Heat Pumps (GHP).
6. Compile information to increase the potential for use of Thermal Distribution Systems Development and Applications.
7. Conduct a Tailored Collaboration entitled "Research on Heat Pump Performance Maps for Incorporation into Building Energy Analysis Calculation Methods" to develop

improved calculation methods that permit more accurate comparison of standard air-source heat pumps and air conditioners with ground-source heat pumps.

Actual Outcomes:

1. Software and information were provided on the performance of zero ozone depletion potential refrigerants.
2. Air-source heat pumps.
 - Version 1.0 was released of EPRI's ESPRE for Windows, which can be used to analyze building energy use as a function of technology.
 - Version 3.0 was released of EPRI's Residential Desk Book, which offers a compendium of information of end-use residential technologies.
 - Brochures were published on dual fuel heating and cooling, sealing heating and cooling systems, and repairing leaky ducts.
 - A newsletter was published on heat pump developments, issues, and markets.
3. Integrated heat pumps.
 - Support was provided to the manufacturer of the PowerMiser integrated heat pump.
 - A brochure was published on marketing integrated heat pumps
 - A brochure was published on the Insider integrated heat pump.
4. EPRI assisted in the development of a comprehensive technician certification program, which merged the testing and certification programs of NATE, ACCA, and RSES.
5. Ground-source heat pumps (GSHPs).
 - A design and installation planning guide was published for GSHPs.
 - A directory was published of GSHP manufacturers and equipment.
 - EPRI hosted the 1999 GeoExchange Industry Conference and Exposition in Sacramento in September 1999.
6. A brochure was published on optimizing thermal distribution systems.
7. Detailed performance map data were collected on both air- and ground-source heat pumps for use in an upgraded analytical procedure to be used in California Title 24 residential building energy compliance evaluations. Several thousand performance maps were obtained, and recommendations were made on analytical procedure modifications.

Project Status: The Commission's participation in this target ended as of December 31, 1999. Participation in the tailored collaboration ended December 2000.

TARGET 7 COMMERCIAL HEAT PUMP/AIR CONDITIONING TECHNOLOGY

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Lennox Industries; ClimateMaster, Inc.; Joint Center for Energy Management-University of Colorado; Alliant Energy; Bevilacqua-Knight Inc; Geothermal Design & Engineering, Inc.

CEC Project Amount: 1999: \$144,500

Match Funding: 1999: \$1,186,322

Contractor Project Manager: Mukesh Khattar
(650) 855-2899

Commission Project Manager: Martha Brook

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to continue developing higher-efficiency, climate-wise refrigerants for the commercial heat pump and unitary air conditioner market. In California, this accounts for approximately one-third of the commercial sector's electricity use. Manufacturers are slowly developing electric equipment for the best refrigerants emerging from research. The slow pace of equipment development is a barrier to the broader use of commercial heat pumps. This project includes developing environmentally superior heat pumps, water-loop, and geothermal systems, and improving indoor air quality and dehumidification. The target also includes work on improved refrigerants and equipment to achieve greater comfort, lower noise, and lower capital and operating costs.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and enhancing the performance and efficiency of heat pump technology for space heating and cooling applications; and
- Improving the environmental and public health costs/risks of California's electricity by reducing energy use which in turn decreases power plant emissions and supporting the changeover from ozone-depleting refrigerants to zero ozone-depleting (ZODP) fluids.

Proposed Outcomes:

1. Provide practical technical information to increase the market penetration of energy efficient heat pumps and new air conditioning technologies.
2. Support development and introduction into the market of commercial heat pump products with substantially improved comfort, efficiency, and environmental impact.
3. Support development and application of Water-loop and Ground-coupled/Geothermal Heat Pump (WL/GCHP) Systems.
4. Support development and application of energy efficient and cost-effective solutions to treat ventilation air and improve indoor air quality and dehumidification.

Actual Outcomes:

1. Technical information.
 - A status review report was published on EPRI commercial heat pump innovations.
 - Updates on industry news were published on refrigerant availability, refrigerant properties, and the ASHRAE 90.1 Standard.
 - The Geothermal Information Office provided information to EPRI members on the use of geothermal systems in commercial and residential buildings.
2. EPRI teamed with Lennox International to develop the first prototypes of Zero-Ozone Depletion Potential commercial rooftop heat pumps with 7.5 and 10-ton capacities. A lab test report was published.
3. Water-loop and ground-coupled heat pump technology.
 - EPRI sponsored development by ClimateMaster of a water-source air heat pump for conditioning of 100% make-up air. The design is more energy efficient than existing units and has features for improved occupant comfort.
 - An evaluation was made of variable pumping strategies and operation of the SmartLoop Controller in buildings with water-loop heat pump systems.
 - A field test report and a tech brief were published on results of energy performance monitoring of a geothermal heat pump in a quick service restaurant.
4. A report was published providing a summary of current and advanced strategies for designing HVAC systems to meet indoor air quality requirements.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

TARGET 9 COMMERCIAL BUILDING THERMAL STORAGE

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Florida State Energy Center; University of Wisconsin

CEC Project Amount: 1999: \$40,000

Match Funding: 1999: \$268,999

Contractor Project Manager: Mukesh Khattar (650) 855-2899

Commission Project Manager: Martha Brook

Commission Contract Manager: Gary Klein (916) 6538555

Project Description: The purpose of this project is to continue developing and implementing thermal energy storage (TES) technology. TES is valued for its proven capacity to trim peak power costs and reduce chiller capacity requirements, often resulting in systems more economical overall than their non-storage counterparts. This can reduce California ratepayers' electric bills and

stretch California electric generation capacity. The importance of these advantages is accentuated by the emergence of refrigerant phaseout issues and real-time pricing. Many customers with facilities well suited to thermal storage are hesitant to move ahead because TES is sometimes seen as an unknown technology.

This project focuses on development of easy-to-use controls for optimal system operation, new analysis methods and data to improve the use of thermal storage in conjunction with real-time pricing, and technology demonstrations to build confidence and use of the technology.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by through development and application of thermal energy storage systems, which can reduce energy bills of California ratepayers.

Proposed Outcomes:

1. Provide information to support the development, application, and commercialization of cool storage technology that is competitive with non-storage equipment in terms of efficiency and cost.

Actual Outcomes:

1. Information to support development, application, and commercialization of cool storage technology.
 - A white paper was published that presented an analysis of the impacts of flexible and real-time price scenarios on the design of thermal energy storage systems.
 - Initial results were published of a field demonstration of a Near Optimal Cool Storage Controller at FirstUnion Stadium in Philadelphia. These results can be used to analyze the viability of thermal storage for specific California sites.
 - An analysis was published of a capacity enhancement approach for chilled water thermal energy storage systems.

Project Status: The Commission's participation in this target ended as of December 31, 1999.

TARGET 28/3 AIRPORT SOLUTIONS

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Hawaiian Electric Company Inc; Carey Transportation; Henry C. Larry

CEC Project Amount: 1999: \$64,000
2000: \$64,000
Total: \$128,000

Match Funding: 1999: \$151,045
2000: \$277,565
Total: \$428,610

Contractor Project Manager: Layla Sandell
(650) 855-2756

Commission Project Manager: McKinley Addy

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to develop new environmental and energy technologies and apply existing technologies, such as electric vehicles, to airport infrastructure to reduce pollution and subsequent costs. In addition, the project will develop improvements to airport efficiency, productivity and safety. Commercial airports are microcosms of all sectors of the electricity marketplace, are major energy users, and are of vital importance to the economic health of their surrounding community. The contribution to local and regional economies from California's largest airports is hundreds of millions dollars every year. However, airports face new and ongoing challenges. Citizens in surrounding communities question the impacts of airports on their quality of life. Reducing overall pollutant emissions from airport facilities has become a high priority issue. These issues could limit airport growth and in turn impact local and regional economies.

Converting ground transportation and other airport equipment to electricity is one solution to these issues. Inside terminals, the installation of electrically powered equipment can improve indoor air quality, reduce HVAC system operating costs, and prevent disruptions in power quality-sensitive equipment. Outside terminals, the use of electrified equipment and vehicles can provide annual operating cost savings exceeding \$500,000. In addition, emission reductions of up to 80 percent could be expected at airports that convert much of their ground transportation and equipment to electricity. EPRI's Airport Solutions Target has developed the necessary methodologies and models to assess the feasibility of electrification and the associated economic and environmental benefits on an airport-specific basis. Through the development and deployment of electrotechnologies, sustainable growth of airports will be enhanced, and energy savings will be attained.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing information on efficiency improvements available for use by airports; and
- Improving the environmental and public health costs/risks of California's electricity by reducing emissions from the internal combustion engines used by airport facilities by

encouraging replacement with electrically-powered equipment.

Proposed Outcomes:

1. Provide information on energy solutions to support the improvement and growth of California airports.

Actual Outcomes:

1. Information on energy solutions for airports.
 - EPRI organized a pioneering project to electrify American Airlines airport ground support equipment (GSE) at Detroit Metro Airport. This first-of-its-kind project electrified 132 pieces of GSE by the end of 2000, and is scheduled to electrify the airline's entire fleet of 1070 vehicles over the next five years. Case study results were published.
 - EPRI hosted an Electric Ground Support Equipment Market Penetration Issues Round Table in June 2000 in Sacramento, CA. The meeting brought together more than 40 representatives of California airports, airlines, vehicle and component manufacturers, a standards-making body, and utilities to address key issues. A proceedings of the meeting was published. A second round table was held in October 2000 at LaGuardia Airport.
 - The latest information was received from the FAA's Inherently Low-Emission Vehicle (ILEV) pilot program, which seeks to achieve environmental benefits through the use of low-emission vehicles.
 - A life-cycle cost-evaluation model and spreadsheet were developed to compare life-cycle costs of electric versus internal combustion-based GSE fleets under different scenarios of operation, thereby assessing the economic benefits of the cleaner airport vehicles.
 - EPRI participated in the planning of a GSE Data Collection Project with Southern California Edison to meter equipment and collect performance, battery management, and metering data.
 - EPRI participated in the planning of a 12-month Power Quality Impact Study involving the characterization of electric GSE charging systems.
 - Information was provided on the environmental benefits of ozonation of cooling towers at an airport in Shreveport, Louisiana.
 - EPRI participated in the National Electric Vehicle Association Infrastructure Working Council (IWC) GSE connector standardization meetings to develop functional specifications for electric GSE connectors, thereby providing a supporting infrastructure for electric GSE, and ensuring safety and reliability of fast charging.

Project Status: The Commission's participation in this target ended December 31, 2000.

TARGET 41 OPPORTUNITIES IN NETWORKED HOME SERVICES

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Paragon Consulting (CA); EH Publishing; Levey Associates; Connect USA, Hoffman Publications; Macro Research; Web Wizard; Centermore Group, Collaborative.com; North-Atlantic Consulting; Phillips; Sony; WebTV; Meternet.

CEC Project Amount: 1999: \$487,000

Match Funding: 1999: \$741,045

Contractor Project Manager: Craig McAllister
(650) 855-1095

Commission Project Manager: Tom Tanton

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to help California ratepayers with telecommunication-based consumer electronics and Internet-based service opportunities related to energy usage, Internet billing, meter reading, appliance control, and energy information. California ratepayers need help to sort through the many choices, find current, accurate information and analyses and perspectives sensitive to energy issues - online, interactive and customized to their needs. This Target is designed to provide California ratepayers with these resources. This Target offers convenient and relevant technology surveillance services, coupled with interactive web-based access to specialists and experts inside and outside the utility industry.

Focus- and custom- EPRI analysis is provided in several key areas:

- Protocols and technical standards, converging technologies, and commercial activity in powerline, telephone, radio frequencies (RF) and cable media;
- Products and vendors of commercially available systems, including integration and management services;
- Projects, market assessments, and economic analysis.

EPRI supports implementation of practical solutions in several ways:

- Builder guidelines for new home networking (expanding on the growing service offering begun with HVAC and heat pump guidelines);
- Mobile and Internet connected networked home showcases;
- Energy Network Computer Information Network systems deployment projects.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by informing California energy users of new technologies

and services to minimize use and cost of electricity and maximize value to the residential ratepayers.

Proposed Outcomes:

1. Provide market, technology, and business analyses to increase the potential of success of new products and services.
2. Provide Networked Home Centers test-bed facilities to increase likelihood of adoption in California.
3. Provide market, technology, and business analyses of Smart Appliances to bring benefits to California ratepayers.
4. Conduct a Tailored Collaboration entitled "Community Network Demonstration" to evaluate the response of an initial focus group of 100 households to low-cost, non-PC-based, consumer access to relevant energy and public benefit information and services.
5. Conduct a Tailored Collaboration entitled "Linked Infrastructure Security Initiative" to provide workshops and educational materials on designing, managing, and evaluating electronic infrastructure security programs for the energy industry.

Actual Outcomes:

1. Analyses of new products and services.
 - EPRI's Home Automation Technology Surveillance service reviewed more than 1500 news releases, conference and meeting presentations, interviews, and markets analyses; wrote more than 400 item summaries; and collated and organized the summaries in three interest categories.
2. Networked Home Centers.
 - Draft floor plan and budget were developed for a Mobile Home Automation Demonstration Showcase. This mobile "home office" will demonstrate networking via the Internet, in-home utility controls, and multiple, switchable meters.
 - Reports were published on Project Res-IDENT and Community Networks.
3. Analyses of Smart Appliances.
 - Analyses of Smart Appliances were provided through one of the interest categories of EPRI's Home Automation Technology Surveillance service (described above).
 - A report was published on residential gateways and controllers.
4. Plans were developed for a pilot project—the Jefferson Project in Clairemont, California—scheduled to be launched in 2000.
5. Tailored Collaboration on Linked Infrastructure Security.
 - Five workshops were organized and facilitated, included two general program workshops and targeted workshops on development of security policy and procedures, operating systems, and legal issues.

- Educational materials were published, including a security primer, DCS/PLC primer, SCADA/EMS primer, guidelines document, and an industry strategy paper.
- A password secured, members-only web site was established for information sharing.

Status:

The Commission's participation in this target ended as of December 31, 1999. The Tailored Collaborations ended December 31, 2000.

TARGET 49/13 POWER MARKETS AND RISK MANAGEMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; The Brattle Group; L.R. Christensen and Associates; The Northbridge Group; Bechtel Group, Inc.; Energoprojekt Consulting SA; Laurits R Christensen Associates Inc; M.S. Gerber & Associates; Marketing Decision Research, Inc; Pattern Recognition Technologies; Strategic Decisions Group

CEC Project Amount: 1999: \$480,000
2000: \$336,000
Total: \$816,000

Match Funding: 1999: \$3,336,827
2000: \$4,366,045
Total: \$7,702,872

Contractor Project Manager: Art Altman (650) 855-8740

Commission Project Manager: Richard Grix
(916) 645-4859

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide a means of understanding risk in the California energy market. Managing risk is a key to competitive electricity prices in California, but traditional analyses cannot accurately reflect the value of resources or risks in today's market. EPRI provides a unique and powerful framework—anchored in modern finance theory—for making decisions with less risk, avoiding huge losses and providing a more stable electricity price environment. EPRI's Electricity Book and other EPRI products extend this tool, and focus on other critical issues, such as forward price curves and ancillary markets. Classes, workshops, and interest groups help Commission staff use all of EPRI's risk management tools quickly and effectively.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by reducing the risk associated with large electricity transactions and providing a more stable California electricity market.

Proposed Outcomes:

1. Provide a comprehensive analysis tool to model the California electricity market and the risks associated with the market.
2. Provide tools to value the benefits and risks of energy market transactions.
3. Provide better Forward Curve estimates to improve energy users' decision making.
4. Provide better understanding of ancillary services.
5. Conduct a Tailored Collaboration entitled "Market Pricing and Market Structure Analysis" to identify critical market pricing and market structure issues within California's new competitive electricity market that influence new market entry and have a direct impact on system reliability.
6. Conduct a Tailored Collaboration entitled "Using Dynamic Simulation to Understand Power Plant Construction Cycles" to modify and enhance an existing simulation tool, which will allow the CEC to model the permitting and construction process and thereby obtain new information on the economics and dynamics of cycles in the building of electric generating capacity.

Actual Outcomes:

1. Analysis tool to model the electricity market.
 - Version 1.10 was released of EPRI's Energy Book System (formerly called Electricity Book), an integrated software package that provides the capability for calculating the value of generating units, and for measuring the risks of transactions. Separate modules are included for pricing and tracking wholesale energy transactions, valuing generation assets, designing retail products, and determining risk exposures.
 - Training and user groups meetings were held.
 - A report was published on describing commodity prices in the Energy Book System.
2. Tools to value benefits/risks of market transactions.
 - Version 1.10 was released of EPRI's Contract Evaluator software, which is designed to value and price wholesale energy transactions and to calculate exposures to wholesale energy markets.
 - Version 1.20 was released of Contract Evaluator, with enhancements that improve the accuracy and speed of the modeling of price movements for risk management and derivative contract pricing.
 - Version 1.10 was released of EPRI's Risk Manager software, which calculates overall portfolio risk based on exposures, market prices, and price volatilities.
 - Version 1.20 was released of Risk Manager, with enhancements similar to Contract Evaluator described above.
 - Two technical reports were published to assist planners in better measuring risks contained in assets and liabilities, and to understand and analyze the hedging strategies to lower those risks.

- Five workshops were held on “Value and Risk Management.”
 - A workshop was held on “Boom/Bust Cycles in the Power Industry: Power Generation Construction Cycles and Implications of Under- and Over-Building of Natural Gas-Fired Power Plants for Energy Markets and Plant Valuation.” Presentations are compiled in a final report.
 - An EPRI Pricing Conference was held.
 - A newsletter was published on the latest EPRI software and tools for power markets and risk management.
3. Forward Curve estimates.
 - A sophisticated suite of tools, methods, and training was provided to assist planners in estimating forward curve price levels and volatilities in California power markets. Chief among these was a report entitled *Forward Price Forecasting for Power Market Valuation*.
 - Specific methods were provided for estimating process parameters—including natural gas prices and loads—which are key inputs to price forecasting.
 - Follow-up advancements were developed for the Forward Curve tools, including a calculation tool for identifying the marginal cost of power at nodes on the California grid, new algorithms for modeling load uncertainty scenarios, and a prototype model to facilitate application of the *FastForward* tool.
 - An assembled package was published entitled “Guide to Process Parameter Estimation Tool Kit,” which includes a CD and a collection of four stochastic process parameter estimation spreadsheets.
 - More than half a dozen introductory and advanced training workshops and user group meetings were held.
 4. Ancillary Services.
 - Measurement and certification tests were conducted at a host generator site. Findings provide insight into understanding methods for measurement and certification, as well as measured values of different ancillary services.
 - A report was produced on key concepts underlying price formation of ancillary services in deregulated markets.
 - A workshop was held on ancillary services pricing, market analysis, and operational issues.
 - Findings were published from a study entitled “The Gas-Electric Interface—A Regional Analysis,” which characterized and interpreted announced capacity additions and determined the extent to which these additions are likely to lead to a net increase in gas consumption.
 5. The tailored collaboration has not started, pending approval from the Commission.
 6. The modeling tool was delivered and demonstrated to the CEC, and a written summary was presented.

Project Status: The Commission’s participation in this target ended as of December 31, 2000. Participation in the Tailored Collaboration entitled “Market Pricing and Market Structure” is pending. Participation in the Tailored Collaboration entitled “Using Dynamic Simulation to Understand Power Plant Construction Cycles” is complete.

TARGET 56/29 GRID OPERATIONS & MANAGEMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; EPRI Conference Blan; ABB Systems Control; Bailey Network Management; Bonneville Power Administration; Cegelec ESCA Corporation; Decision Systems International; Duquesne Light Company; General Physics Corporation; General Reliability; Houston Lighting & Power Company; Incremental Systems, Inc.; Iowa State University; Kansas City Power & Light Company; KEMA Consulting, KEMA-ECC, Inc; Oracle Corporation; Pattern Recognition Technologies; Potomac Electric Power Company; Quality Training Systems; Siemens Energy and Automation, Inc.; Siemens/Empros; TU Electric Company; University of Liege; Utility Consulting International; V&R Company; Energy Systems Research; Warsaw University of Technology; Washington State University

CEC Project Amount:

1999:	\$190,000
2000:	\$180,000
Total:	\$370,000

Match Funding:

1998:	\$4,838,558
1999:	\$4,739,264
2000:	\$4,951,836
Total:	\$9,691,100

Contractor Project Manager: Dan Sobajic (650) 855-8537

Commission Project Manager: Don Kondoleon

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to support EPRI’s collaborative program in Grid Operations and Management, which is developing new tools and information to ensure that the power grid will be a gateway to efficient competition and the key to customer satisfaction. EPRI provides tools and information that offer guidance on how to respond to demands to safely push more power through the system without jeopardizing system security. EPRI’s products give system operators a clear view of real-time grid conditions, and allow them to make decisions that take into account maximum use of the grid as well as reliability of the system. Examples include vital resources to support operator training, real-time software for Energy Management System (EMS) control and operation, and seamless communication between Energy Management Systems and power plants.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system: and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Provide software, methods, and information to enhance the transaction management capabilities of transmission system operations, and to allow increased transactions without impact on security.
2. Provide software, methods, and information to maximize energy transfers and increase energy flows across constrained interfaces.
3. Provide software, methods, and information to increase the transmission system capacity.
4. Conduct a Tailored Collaboration entitled "EPRI Early Warning System Project" to identify and report Y2K anomalies and events in electric and natural gas operations from 12/31/99 through 1/4/00.

Actual Outcomes:

1. Transaction management
 - Version 1.4 of the transaction management software Open Access Same-time Information System (OASIS) software was developed. A response was prepared to FERC Order 638 to enhance the functionality and performance of OASIS business practices.
 - A variety of open-system, standardized tools were provided that will permit the CA-ISO to implement advanced security applications without regard for existing proprietary databases. Tools include Version 1.0 of the Application Program Interface (API), which enables users to integrate applications from various sources, and a Topology Processor, which allows applications developed for planning environments to be integrated into operating environments.
 - Two reports were published on the Common Information Model (CIM), which provides a common language for information.
 - New graphical user interfaces were developed for existing grid operations applications to ensure they have a consistent look-and-feel.
 - EPRI's Operator Training Simulator was integrated with API and CIM to allow operators to be trained with CIM data.
 - Five restoration lessons were produced for the

Emergency System Management and Restoration (ESMR) product.

- A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
 - A report was published summarizing grid operations and planning issues, needs, technological advances, and regulatory changes in the 2000-2005 time frame.
2. Increase power flows
 - Version 2.0 was released of EPRI's Transfer Capability Evaluation (TRACE) software, which allows system operators to determine the maximum number of simultaneous power transfers possible.
 - TRACE was integrated with IEEE PSADD Common format to support the latest version of Power Technologies' PSS/E data formats.
 - A TRACE training workshop was held.
 3. Increase transmission capacity
 - EPRI's Dynamic Security Assessment (DSA) software was made available. DSA allows operators to increase loading on constrained networks by calculating stability limits on-line in real time.
 - Two reports were published on DSA and Risk-Based Security Assessment.
 - Version 1.1 was released of EPRI's On-line Voltage Security Assessment (VSA) software, which allows system operators to increase power transfers across voltage-constrained networks by calculating voltage limits on-line in real-time.
 4. A web site was established and operated to communicate information about the actual operating experience of selected locations during the year 2000 rollover.

Project Status: The Commission's participation in this target is ongoing. Participation in the tailored collaboration ended December 31, 1999.

TARGET 61 KNOWLEDGE-BASED CUSTOMER METERING; 61.1 TECHNOLOGY DEVELOPMENT; AND 61.2 MARKET RESEARCH AND SERVICES DEVELOPMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Advanced Systems Associates; Hypertek, Inc.; Plexus Research Inc; Advanced Systems Associates; Arizona State University

CEC Project Amount: 1999: \$266,500

Match Funding: 1999: \$1,165,930

Contractor Project Manager: Dave Richardson
(650) 855-2331

Commission Project Manager: Tom Tanton

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide electricity consumers with intelligent, time-of-use electric meters with built-in communications to enable utilities and their customers to utilize innovative activities such as automatic meter reading and energy utilization analysis. An important part of industry restructuring is customization of service—providing new choices and new benefits to individual clients. Some customers may be attracted by new ways to lower their electricity bills, while others are already demanding premium power quality. Beyond the differentiation of electricity service, new opportunities are also arising for convergence of multiple utility services—including gas, telephone, home security, and Internet access—through a single provider. In each of these areas, more sophisticated customer interface technology will be needed to meet the data collection and communications requirements of the utility service revolution with customers and suppliers benefiting from detailed load and billing information.

New meter technology applications are being developed using the EPRI collaborative research approach to reduce development costs and risks. New products developed during these projects will be available to members for beta testing and at preferential pricing when the product has been commercialized. A prepayment meter is under development to give customers the flexibility of prepaying specific sums, just as telephone cards are now doing. A non-intrusive appliance load monitoring (NIALMS) module will be developed to provide a better understanding of residential energy usage leading to improved time of day pricing service. Tamper detection and research hold out the promise of reducing the number of billing irregularities. This EPRI target also develops market research into new metering service packages. Members will have an opportunity to participate in the research and select the target customers and demographics. Market data and analysis developed during these projects will be available to members for early adoption.

This project supports the PIER Program objectives of:

- Improving the quality of California's electricity by providing advanced meters with the intelligence, flexibility, and communication capability to allow automated meter reading, real-time pricing, and energy management services: and
- Improving the energy cost/value of California's electricity by enabling the delivery of value-added electricity services to customers through advanced meters.

Proposed Outcomes:

1. Produce a commercial product—the SE-240 electronic residential meter—which is cost competitive with existing

meters on an evaluated basis, while providing an array of additional services.

2. Develop information on residential customers' responses to new types of services made possible by advanced meters and communications systems.
3. Develop information on metering technologies and their applications to provide maximum choice and value to customers.

Actual Outcomes:

1. SE-240 electronic residential meter.
 - Prototypes of the meter were field-tested by 47 utilities, and 19 vendors were engaged in the manufacture of plug-in modules. A technical progress report was published.
 - A prototype meter was released with an internal disconnect switch to be used for remote disconnect to prevent lost revenue.
2. Information on customers' responses to new services.
 - A comprehensive review was published of available information on prepayment metering in North America, including business issues, customer acceptance, regulatory issues, and available products.
 - A report was published identifying new energy services being offered today in residential and commercial markets by electric utilities and energy service companies.
3. Information on metering technologies.
 - Up-to-date information on business issues and technology developments was compiled on the Metering Industry and Product Development web site.
 - Field audits were conducted and a report published on metering revenue losses due to theft, meter misinstallation, and meter malfunction.
 - Support was provided to national standards setting organizations for open architecture for metering design. The minutes were published of the ANSI C12 Committee Meeting.

Project Status:

The Commission's participation in this target ended as of December 31, 1999.

TARGET 91, AIR TOXICS HEALTH AND RISK ASSESSMENT

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Atmospheric & Environmental Research Inc; Exponent Failure Analysis Associates; Golder Associates Inc; ICF Kaiser Engineers; Lockheed Martin Energy Systems Inc; Raptor Research Project; SCOPE; Tetra Tech Inc; University of Connecticut; University of Maryland; University of Nevada, Reno; University Of Rochester; Wisconsin Department of Natural Resources.

CEC Project Amount: 1999: \$507,250

Match Funding: 999: \$3,233,763

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Project Description: The purpose of this project is to determine whether trace substances emitted by power plants may be deposited near the emissions sources or be transported over great distances. At issue is whether power plant contributions pose concerns for human health and environmental quality. Currently, air toxics such as dioxins, arsenic, nickel, and especially mercury are of growing regulatory, public, and economic concern. Recent U.S. EPA reports to Congress address the relationship between these toxics and power plant emissions, and call for extensive research into several key questions: How toxic is the material emitted by power plants? To what extent, and by what means, are people exposed to that material? How can a realistic estimate of quantitative risk be derived? What risks are significant? Basic scientific understanding of these issues is critical to the energy industry.

The primary focus of this EPRI target is filling gaps in scientific and health information. EPRI research is designed to inform energy companies and policy-makers of the health and environmental basis for potential risks associated with air emissions and, when appropriate, to examine practical management solutions. This target, combined with the other EPRI research on air toxics measurement and control, provides a total integrated response to the issues cited above. EPRI's comprehensive risk-assessment framework has also been critical in supporting informed and cost-effective community health decisions. By providing objective and timely information, EPRI promotes science-based decision making on air toxics.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by providing science-based assessment of air toxics health and risk impacts; and
- Improving the safety of California's electricity by assessing the risk of power generation with regard to air toxics, by providing science-based assessment of air toxics health and risk impacts.

Proposed Outcomes:

1. Provide advanced tools and data to evaluate public exposure to mercury and other substances, including dioxins, with significant non-inhalation exposure routes.

2. Quantify atmospheric mercury concentrations and deposition in time and space to establish local versus regional/global influence.
3. Evaluate natural mercury emissions to provide a more accurate context for perspectives on power plant mercury emissions.
4. Determine source-receptor relationships for air toxics (with emphasis on mercury).
5. Assess health effects of nickel exposure.
6. Assess health effects of exposure to arsenic and other air toxics.
7. Provide data enhancements to the Mercury Cycling Model System.
8. Update and refine the Comprehensive Risk Assessment Framework for Toxics (CRAFT) model.
9. Evaluate ecosystem effects of mercury exposure by performing an ecological risk assessment of mercury impacts on fish-eating wildlife.
10. Determine environmental consequences of ecological and human exposure to multiple toxic agents, including arsenic, mercury, and selenium.
11. Conduct a Tailored Collaboration entitled "Risk Evaluation of Chemicals Used in the Photovoltaic Industry in California" in order to identify chemicals used in PV cells and their potential for release to the environment, and to identify PV cell technologies that have a relatively lower toxic risk compared to other cell types.

Actual Outcomes:

1. The EPRI TRUE multimedia model was extended for exposure to dioxins, by specifying congener-specific dynamics, and was adapted to the Mercury Cycling Model for lake-specific outcomes.
2. Quantifying atmospheric mercury concentrations and deposition.
 - Information was compiled from continuous measurement of wet deposition of mercury at the Covelo, California, deposition monitoring station.
 - Field measurements of mercury source terms were conducted in central coastal California and at sites in the eastern Sierra, which were disturbed by mineral recovery operations over the last 150 years.
3. Natural mercury emissions were evaluated, and a research project by EPRI staff was published in 2000, indicating contributions to mercury deposition by background emissions.
4. Additional case studies and a national study were carried out, establishing the contribution of local and international sources to U.S. mercury deposition. A report was issued in December 2000.
5. A report was published on the comparative carcinogenicity of nickel compounds.
6. Proceedings were published from the Fourth International Conference on Managing Hazardous Air Pollutants.

7. D-MCM 1.0 was released for the Dynamic Mercury Cycling Model.
8. Additional specialized modules for CRAFT were developed in case studies. Full development has been postponed by resource limitations.
9. Extensive work on ecosystem risk is under way, with published results in 2000 on fish levels of mercury and on levels and effects in avian fauna.
10. Proceedings were published from the Fourth International Conference on Managing Hazardous Air Pollutants.
11. A final report is expected to be published in mid-2001.

Project Status: The Commission's participation in this target ended as of December 31, 1999. Participation in the Tailored Collaboration ended December 2000.